

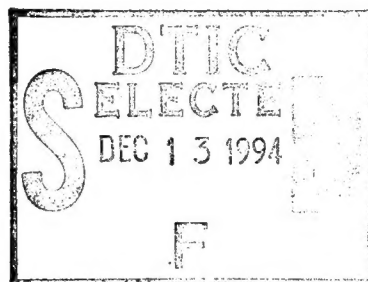


US Army Corps  
of Engineers  
Waterways Experiment  
Station

Technical Report EL-94-13  
October 1994

# A Survey of the Black Warrior and Tombigbee Rivers, Alabama, for the Threatened Inflated Heelsplitter Mussel *Potamilus inflatus*, May 1993

by Andrew C. Miller



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by Andrew C. Miller

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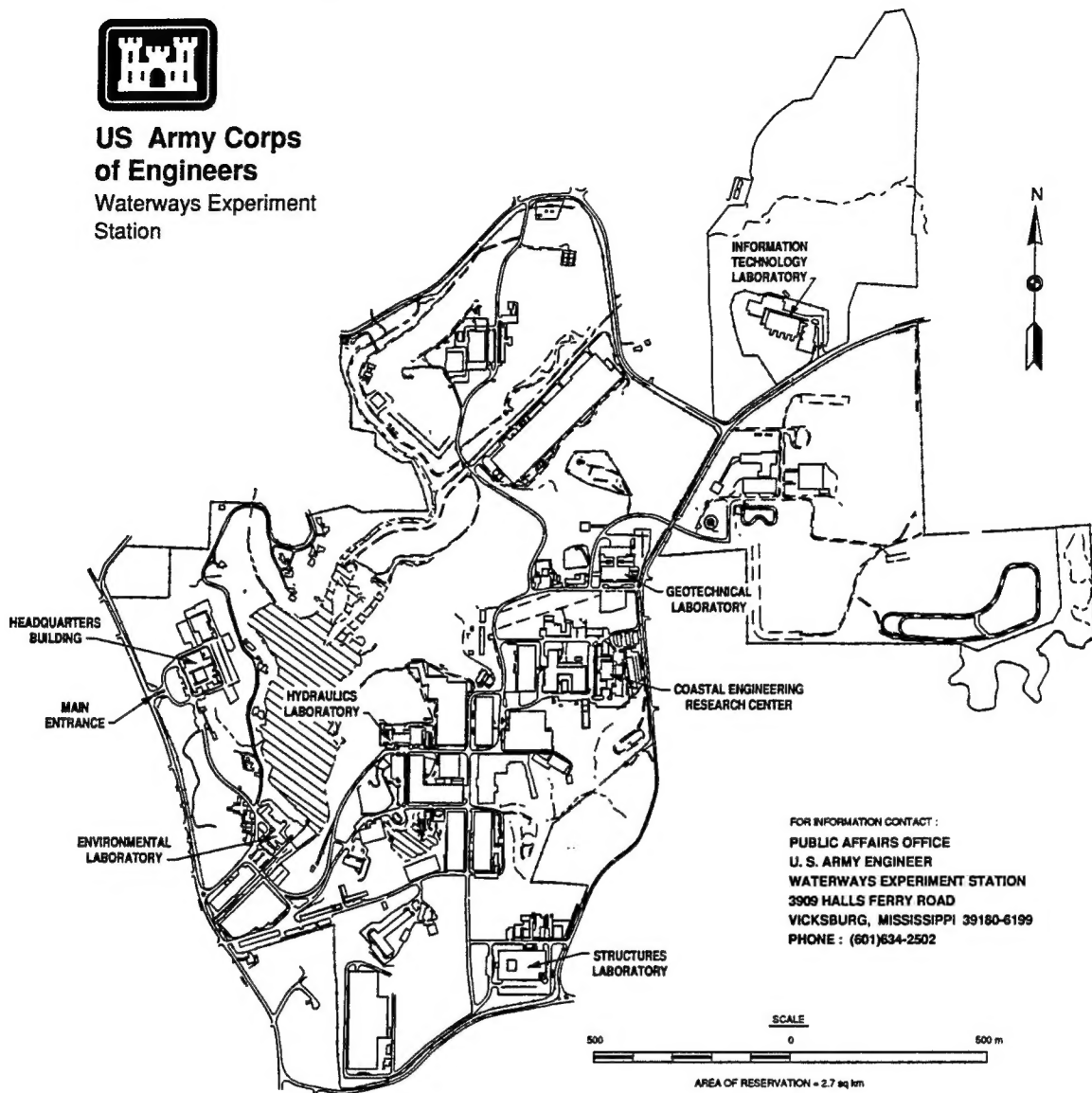
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# Preface

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Selected dredged material disposal areas along reaches of the Black Warrior and Tombigbee rivers, Alabama, were surveyed 19-24 May 1993 for the threatened inflated heelsplitter mussel *Potamilus inflatus*. Studies were conducted by personnel of the U.S. Army Engineer Waterways Experiment Station (WES) with diving support from the Tennessee Valley Authority (TVA). Funds for this work were provided by the U.S. Army Engineer District, Mobile, and the Water Operations Technical Support Program at WES.

The study reported herein was designed by Drs. Andrew C. Miller and Barry S. Payne, Aquatic Ecology Branch (AEB), Ecological Research Division (ERD), Environmental Laboratory (EL), WES, with assistance by Mr. Brian Peck, Mobile District, and Mr. Leroy Koch, U.S. Fish and Wildlife Service Field Office, Daphne, AL. Mr. Peck also provided information on locations of study sites and reviewed an early draft of the report. Dr. Miller prepared this report.

Divers for this study were Messrs. Larry Neill, Robert T. James, Jeff Montgomery, and Kevin Chalk. Assistance in the field was provided by Mr. David Felder, Millsaps College, and Ms. Deborah Shafer, WES. Ms. Shafer was the WES diving inspector for this project. Ms. Sarah Wilkerson, Mississippi College, prepared figures, and Ms. Geralline Wilkerson, Hinds Junior College, prepared tables. TVA personnel provided safety equipment, foul weather gear, and a global positioning system.

During the conduct of this study, Dr. John Harrison was Director, EL; Dr. Conrad J. Kirby was Chief, ERD; and Dr. Edwin Theriot was Chief, AEB.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

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# Conversion Factors, Non-SI to SI Units of Measurement

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Non-SI units of measurement used in this report can be converted to SI units as follows:

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
feet	0.3048	meters
miles (U.S. nautical)	1.852	kilometers

# 1 Introduction

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## Background

The U.S. Army Engineer District, Mobile, dredges and disposes of dredged material at selected areas along the Black Warrior and Tombigbee (BWT) rivers, Alabama (U.S. Army Corps of Engineers 1987). Dredging is at a depth of 9 ft plus 4 ft of overdredge and is designed to maintain a 200-ft-wide channel.<sup>1</sup> "Within Banks Disposal Areas" are used so that dredged material will be placed along the shore or in shallow water within banks and could be subject to the erosive action of high water.

Disposal areas are near sites where the inflated heelsplitter mussel *Potamilus inflatus* has been collected (Stewart 1992). This species, listed as threatened by the U.S. Fish and Wildlife Service (FWS) in 1990, has also been found in the Amite River, Louisiana (FWS 1991). Stern (1976) reported that *P. inflatus* usually inhabits soft, stable substratum in slow to moderate current. The inflated heelsplitter has been found in sand, mud, and sandy gravel substrate, but not in large gravel or armored gravel (Hartfield 1988a,b). This species is similar to the pink heelsplitter (*Potamilus ohiensis*). However, the latter species is less inflated and found in sloughs and lakes where *P. inflatus* has not been collected.

The FWS, Daphne, AL, prepared a Biological Opinion on the effects of dredging and disposal of dredged material on *P. inflatus* for the BWT rivers. In the Biological Opinion sent to the Mobile District on 5 March 1993, the FWS stated that "dredging and disposal would adversely affect the inflated heelsplitter mussel" (FWS 1993). They also noted that this species has continued to exist in the BWT rivers despite dredging and other impacts. The FWS concluded that various mitigative features of the proposed dredging project (searching for the inflated heelsplitter mussel at dredge disposal areas and a commitment to relocate mussels or disposal areas as necessary) will help to reduce impacts. The opinion of the FWS stated that dredging and disposal, including maintenance of small boat channel accesses, is not likely to jeopardize the continued existence of the inflated heelsplitter mussel. As a result, the

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<sup>1</sup> A table of factors for converting non-SI units of measurement to SI units is presented on page vi.

Mobile District surveyed disposal areas for this species prior to the placement of dredged material and will initiate protective measures as necessary.

## Purpose and Scope

The purpose of this study was to survey dredged material disposal areas along the BWT rivers, Alabama, for freshwater mussels, especially the *P. inflatus*. Surveyed disposal areas along the Tombigbee River were located between River Mile (RM) 65.0 and RM 190.0; on the Black Warrior River, disposal areas were located between RM 293.0 and 334.0. The survey was conducted on 19-24 May 1993. This report also addresses "Reasonable and Prudent Measures" to protect *P. inflatus* that were recommended in the Biological Opinion.

## 2 Study Area and Methods

---

### Study Area

The Black Warrior River originates north of Tuscaloosa in north-central Alabama, flows south to the Tombigbee River where it enters at RM 217.0 near Demopolis, AL (Figure 1). The original source of the Tombigbee River was in northeastern Mississippi. It flowed south and east before entering Alabama just west of Tuscaloosa. As a result of completion of the Tennessee-Tombigbee Waterway in the 1980s, the Tombigbee River now connects with the Tennessee River in eastern Mississippi. After being joined by the Black Warrior River, the Tombigbee River flows south toward Mobile, AL. The Alabama River enters the Tombigbee River at RM 46.6, and the two rivers become the Mobile River.

Disposal areas for evaluation were located between RM 334.0 and RM 293.0 on the Black Warrior River and between RM 190.0 and RM 65.0 on the Tombigbee River. Seventeen and eleven disposal areas were investigated on the BWT rivers, respectively, (Figures 2-4). Sediments at disposal areas consisted mainly of sand (grain); particle size ranged between 0.08 and 5.0 mm (Table 1). Gravel comprised less than 2 percent of most samples except for Site 21, replicate 2 (Sunflower Cutoff Bar) where it was 36.7 percent. Fines (particle sizes less than 0.08 mm in diameter) ranged from slightly less than 1 to more than 40 percent of the sample, although the majority of the values were less than 5 percent. Organic content of sediments was low and ranged from 1.8 to 3.1 percent, and water content ranged from 11.8 to 35.1 percent (Table 2).

### Methods

All underwater work was accomplished by a four-person dive crew with surface-supplied air and communication equipment. Two divers working simultaneously searched a transect along the river bottom for mussels. Each diver entered the water near the channel, worked toward shore, moved upriver, then worked out toward the channel again. The total search time under water was recorded. It was estimated that divers searched approximately 5 sq m per minute.

All mussels were brought to the surface, counted, and identified. Total shell length and inflation (maximum width of each individual) of *P. inflatus* were recorded. All *P. inflatus* were held in 20-l buckets during the survey, then replaced in the substratum at locations that would not be dredged. Selected specimens of nonendangered species were retained for voucher.

Methods for sampling mussels were based on techniques described in Coker (1919); Brice and Lewis (1979); Miller and Nelson (1983); Isom and Gooch (1986); Kovalak, Dennis, and Bates (1986); and Miller and Payne (1988). Mussel identification was based on taxonomic keys and descriptive information in Murray and Leonard (1962), Parmalee (1967), Starrett (1971), and Burch (1975). Mr. Paul Hartfield, FWS Endangered Species Office, Jackson, MS, verified nonendangered species and provided a reference specimen of *P. inflatus* to take into the field. Nomenclature is consistent with Turgeon et al. (1988).

All calculations were done with programs written in BASIC or SAS (Statistical Analytical System) on a personal computer. Discussion of statistical procedures that were used can be found in Green (1979) and Hurlbert (1984). Species area curves were constructed from qualitative data.

## 3 Results

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### Density

Two divers surveyed a total of 69 locations on the BWT rivers on 19-24 May (Table A1 and A2, Appendix A). From one to five searches for mussels (using two divers) were completed at each of 28 disposal areas. Biotic data (number of bivalves and *P. inflatus* collected/100 sq m and per minute) obtained by each of the two divers appear in Tables A3 and A4, respectively. Results of both divers have been compiled and appear in Table A5. A listing of mussels collected at each disposal site appears in Table A6. Table 3 was prepared by summarizing all replicates for each of the 28 disposal areas from Table A5. Total dive time for both divers ranged from 20 to 145 min at the 28 disposal areas (Tables 3 and 4). At the rate that divers worked (approximately 5 sq m/minute), the amount of river bottom searched ranged for each dive from 100 to 725 sq m.

Bivalve densities were extremely low at all sites surveyed. When present, total bivalves (which included native mussels as well as the Asian clam *Corbicula fluminea*) ranged from 0.104 to 4.817/100 sq m. At six disposal areas, divers found no live mussels. When present, mussels were found at a rate of 0.005 to 0.241/minute of collection time. The maximum density of *P. inflatus* was 4.5/100 sq m collected at a rate of 0.228/minute (Figures 5 and 6).

Based on density data (Table 3), the study area was divided into four reaches (Table 5, Figures 2-4). Reach 1 (RM 334.0-323.5) had extremely low bivalve density (0.200 individuals/100 sq m). Reach 2 (RM 323.3-300.9) had the highest density (2.177 individuals/100 sq m). Reach 3 (1.377 individuals/100 sq m) and Reach 4 (RM 107.0-65.4) were characterized by moderate density (0.183 individuals/100 sq m). *Potamilus inflatus* was totally absent from the fourth reach. It was of comparatively low, high, and moderate density in Reaches 1, 2, and 3, respectively (Figures 7 and 8).

### Ability to Collect *P. inflatus*

A comparison of the cumulative number of individuals collected versus the amount of time expended provides a graphical depiction of sampling effort. A

total of 1,610 min (26.8 hr) were spent searching in the study area. After about 1,000 min had been expended, a total of nine species of bivalves (the total collected) had been found (Figure 9). Regardless of where samples were collected, new species were collected at approximately one every 110 min.

The reduced number of bivalves (and *P. inflatus*) in the entire study area is illustrated in Figures 10 and 11. After about 500 min had been expended, five bivalves (and only a single *P. inflatus*) had been collected. In the center portion of the study area (Reaches 2 and 3), all species of bivalves were collected more rapidly. In Reach 2, the portion of the study area with highest densities, total bivalves and individual *P. inflatus* were collected at the rate of one per 11.3 and one per 15.3 min, respectively.

Of the 63 bivalves collected during the survey, *P. inflatus* comprised 52.4 percent (Table 6 and Figure 12). *Leptodea fragilis* (fragile papershell), also a thin-shelled species, ranked second in abundance and comprised 12.7 percent of the assemblage. Thick-shelled species, usually found in firmly packed gravel substratum, comprised only 19 percent of the fauna.

The actual size of each disposal area was estimated to range from approximately 6,400 to 67,590 sq m (Table 7). Twenty-eight disposal areas included a total of 1,116,854 sq m. Based on the density of *P. inflatus* and the size of each disposal area, the possible number of inflated heelsplitters present was estimated (Table 8). Based on the rate of collection, 2,120 diver hours could be required to collect all *P. inflatus* present.

Although considerable effort was expended during this survey, a comparatively small amount of each disposal area was actually surveyed (Table 9). Divers actually surveyed from 0.18 to 2.02 percent of each of the 28 disposal areas. Summary information, including the total time expended, area surveyed, and bivalves collected, appears on Table 10.

## Factors Affecting Presence of *P. inflatus*

All disposal areas are not used each year. The number of years since the last dredging at each area ranged from 1 to 10 between 1981 and 1992 (Table 11). The total number of years within this time period that disposal took place ranged from 1 to 8. Estimates of density at each disposal area were used to determine if there were relationships between disturbance caused by disposal and the total number of *P. inflatus* present. Relationships between total material dredged, total number of years of dredging, and the total number of years since dredging took place, were nonsignificant ( $P > 0.05$ , Figures 13-15).

There was no significant relationship between percent fines (particles less than 0.08 mm in diameter) and density of *P. inflatus* (Figures 16-17).

Previous workers have reported that *P. inflatus* is usually collected in fine-grained substratum (Hartfield 1988a,b). Sediment samples were taken at disposal areas close to the location where divers searched for mussels. It is possible that *P. inflatus* was collected in an area of extremely high, but localized, sediment deposition. Different results might have been obtained if sediment for analysis were taken at the exact location where *P. inflatus* was collected.

## Small Boat Channels

On 24 August 1993, two individuals surveyed disposal areas for six small boat channels in the Black Warrior River and seven in the Tombigbee River. Three hundred and seventy-two minutes were spent searching, and 25 mussels and six species were collected (Table 12). Mussel densities were low; the maximum mussel collection rate was 0.267 individuals/minute. The inflated heelsplitter mussel was found only at RM 227.0 in the Black Warrior River. Of the 13 disposal areas for the small boat channels examined, live mussels were found at only three locations.

## 4 Discussion

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### Rate of Collecting Mussels

In the spring of 1993, personnel of the FWS Endangered Species Office, Jackson, MS, searched for *P. inflatus* near RM 327.3. Five divers worked a total of approximately 100 min and collected 26 live *P. inflatus*. The rate at which FWS personnel collected this species, 0.26/minute, is similar to the average rate *P. inflatus* was collected at McGowin Bluff during the present survey (0.228/minute). Although personnel and techniques differed slightly between the two surveys, it is apparent that similar results were found for this river reach regardless of personnel and methods.

Rates for collecting mussels in the BWT rivers, less than 0.3/minute, are far less than data from other rivers. For example, at a moderately dense mussel bed in the Sunflower River, Mississippi, mussels were collected at a rate of 1.5 to 8.9/minute (Miller and Payne, unpublished information). At a site in Pool 7 of the upper Mississippi River, divers collected 2,087 mussels and 23 species in slightly less than 700 min. Mussels were collected at a rate of approximately 3.1/minute. In the present survey, 63 mussels were collected in 1,610 min.

### Density

Density of mussels at disposal areas can be considered extremely low when compared with results of other surveys. Maximum mean density was 4.8/100 sq m or 0.05/sq m. At a shallow water site in the Big Sunflower River, Miller, Payne, and Hartfield (1992) reported density of thick-shelled species of 93.8/sq m. At six sites in the lower Tennessee River, mean density of Unionidae ranged from 9.2 to 128.0/sq m and mean density of *C. fluminea* ranged from 6.0 to 26.4 individuals/sq m (Miller, Payne, and Tippet 1992).

## Presence of *P. inflatus*

Thin-shelled species dominated the project area. *Potamilus inflatus* and *L. fragilis* comprised 52 and 13 percent, respectively, of the fauna (Table 6). *Corbicula fluminea*, a species that lives 2 to 3 years, comprised 11 percent of the fauna. The remaining bivalves consisted mainly of thick-shelled (*Quadrula* spp.) and moderately thick-shelled species (*Lampsilis teres* (yellow sandshell) and *Lasmigonia complanata* (white heelsplitter)). Most mussel beds in large rivers are dominated by thick-shelled or moderately thick-shelled species. In the lower Tennessee River, *Amblema plicata plicata* (three ridge) and *Fusconaia ebena* (ebony shell) together comprised nearly 80 percent of the Unionidae (Miller, Payne and Tippet 1992). At shallow water sites in the Big Sunflower River, Mississippi, *A. p. plicata* comprised approximately 74 percent of the Unionidae (Miller, Payne, and Hartfield 1992).

The substratum in the project area was characterized by sand and silt with small quantities of gravel. Extensive stable sand and gravel shoals that provide good habitat for long-lived thick-shelled mussels were not a prominent feature of the study area. *Potamilus inflatus* and other thin-shelled species are mobile and well-adapted to fine-grained, unstable substratum. Highly mobile species survive well since they are able to move to avoid being smothered by sand. These species would have poor survival in coarse gravel or cobble where they could be crushed. *Corbicula fluminea* is found in sand as well as gravel and sand. Since this species is quite mobile, it can avoid burial by sand or silt. In addition, the species is recruiting in the project area; several individuals less than 10 mm long were collected (Table A6).

## Effects of Dredging and Disposal on *P. inflatus*

There is considerable variation in the frequency of use and the amount of material deposited at 28 disposal areas (Table 11). However, there appeared to be little or no relationship between amount of material dredged, number of years since last dredging, or the total number of years between 1981 and 1992 that the disposal area was used, and the density of *P. inflatus* (Figures 13-15). *Potamilus inflatus* is more likely to be found in fine-grained as compared with coarse-grained substratum. (Hartfield 1988a,b). However, the relationships between percent fines and density of total bivalves or total *P. inflatus* were low (Figures 16 and 17). These relationships could have been improved if sediment samples were taken at exact locations where mussels were collected.

## Methods for Protecting *P. inflatus*

The effects of disposal of dredged material in the BWT rivers on individual *P. inflatus* could be reduced. More detailed information on habitat requirements (water depth, distance to shore, etc.) of the inflated heelsplitter in the

study area could be obtained. Detailed information on the disposal process (thickness of recently disposed material and exact location of placement) could be obtained. It is possible that slight changes in the disposal process could reduce any potential impacts to *P. inflatus*.

Because thin-shelled species are highly motile, they are suited for existence in sand and silt substratum. The ability of *P. inflatus* to extricate itself once buried at different depths in sand or silt should be evaluated and quantified. Thin-shelled mussels such as the inflated heelsplitter can tolerate shallow burial, whereas thick-shelled species cannot. More detailed information on the tolerance of this species to burial could assist in the development of strategies for its protection.

Surveys for *P. inflatus* described in this report were conducted in disposal areas with moderately stable sand and silt substratum. Areas in these rivers not used for disposal and with more stable substratum could be found. Detailed quantitative and qualitative studies could be conducted to determine if *P. inflatus* is present and to characterize the associated bivalve populations. Information on *P. inflatus* in more stable substratum not impacted by disposal could be used to understand the effects of disposal of dredged material on this species.

## Summary

The inflated heelsplitter mussel *P. inflatus*, listed as threatened by the FWS, was found in extremely low densities at dredged material disposal areas for navigation channel maintenance and small boat channels in the BWT rivers, Alabama. The substratum at these disposal areas consisted mainly of sand and silt and was not stabilized by cobble or gravel. The mussel fauna at these disposal areas was dominated mainly by rapidly growing, highly mobile, thin- and moderately thick-shelled mussel species. Species that tolerated these conditions are most able to move quickly to avoid being smothered by moving sands and silt.

There were no significant relationships between density of *P. inflatus* and the amount of dredged material, number of years since the last dredging cycle, or the total number of years (since 1981) that dredging had occurred. It is likely that a general lack of substrate stability of these disposal areas is the principal reason that *P. inflatus* is uncommon in the study area.

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Corps of Engineers, Mobile, Mobile, AL.

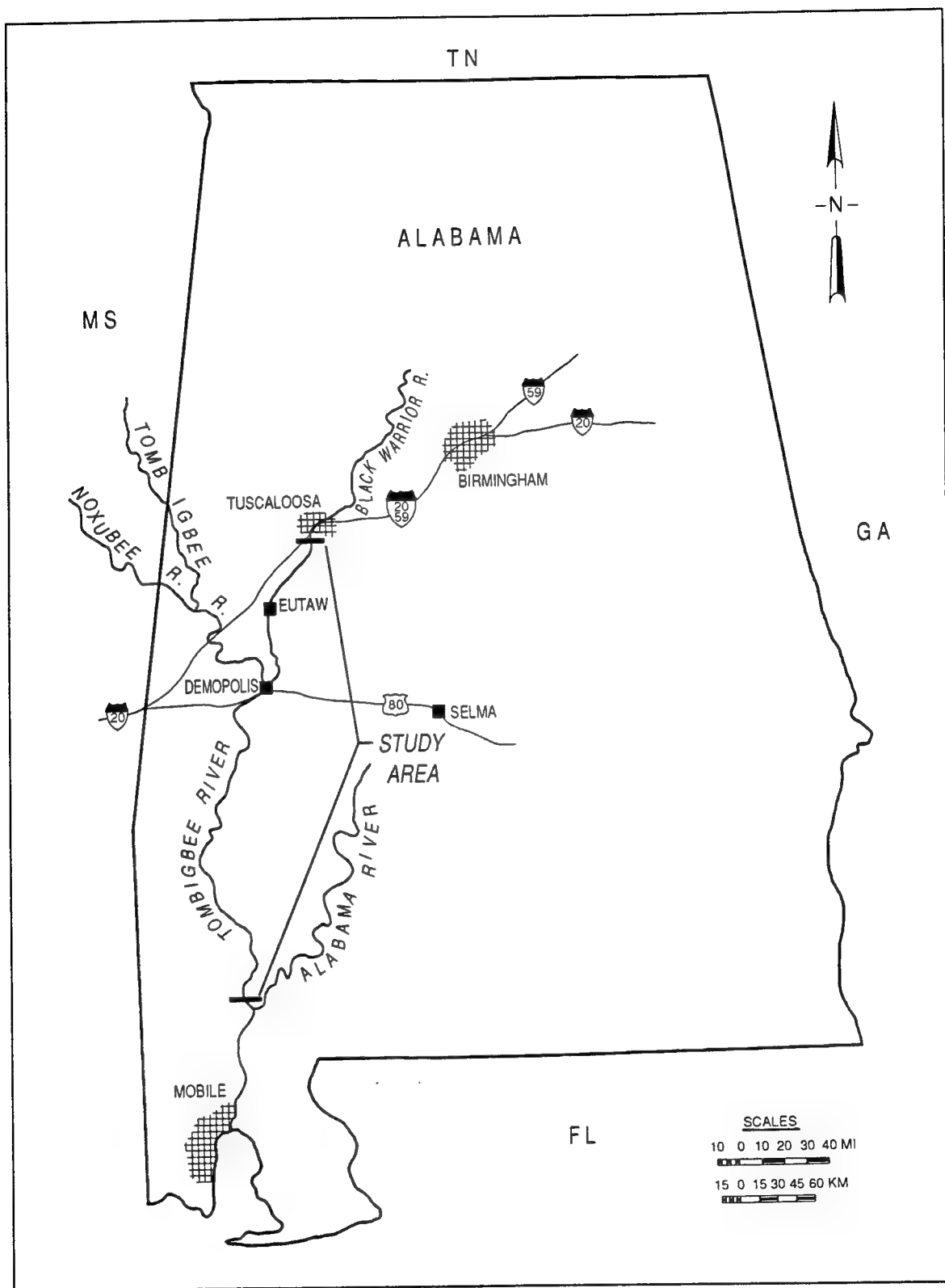


Figure 1. Map of the study area

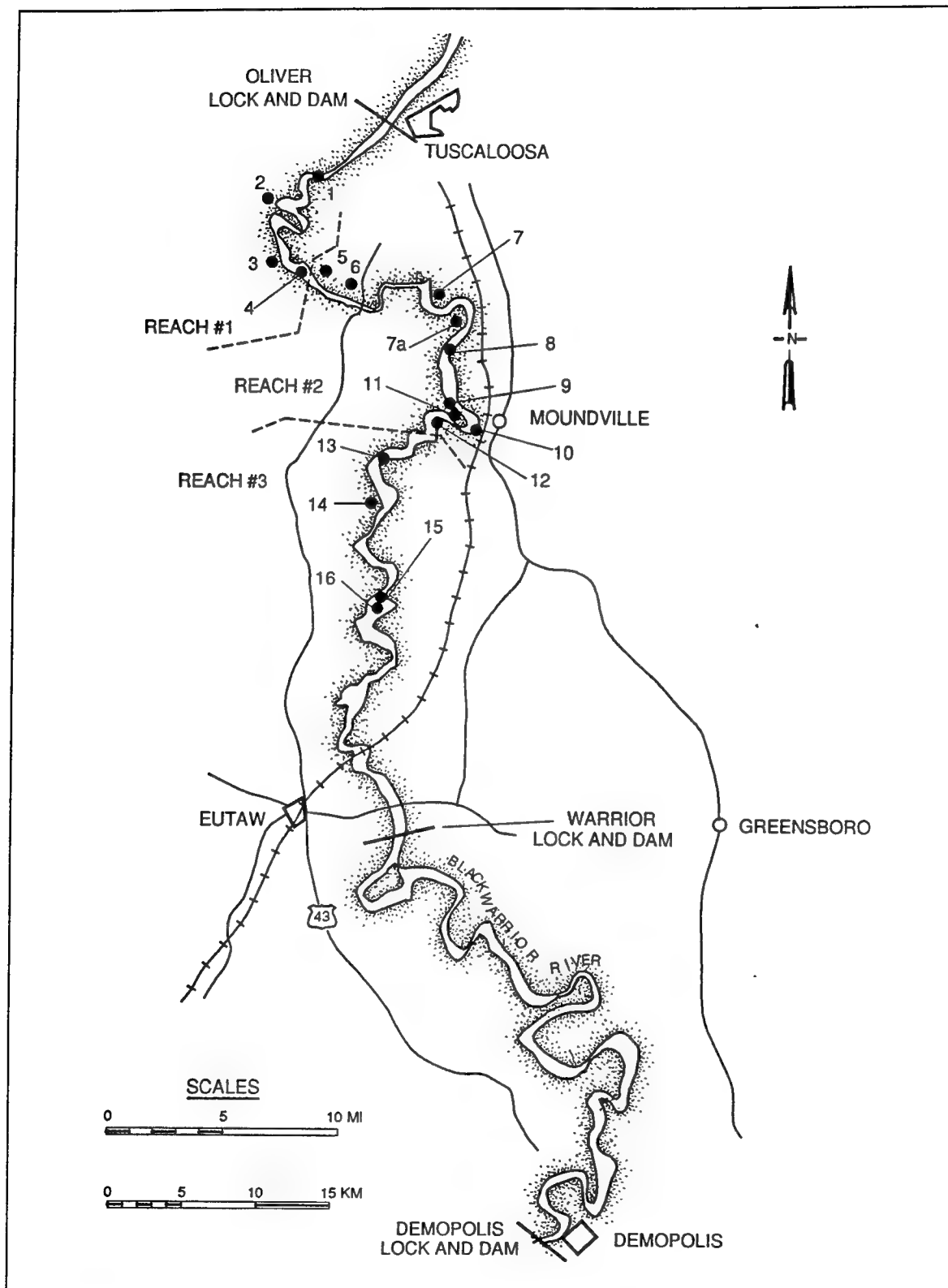


Figure 2. Location of disposal areas 1-16, Black Warrior River, Alabama

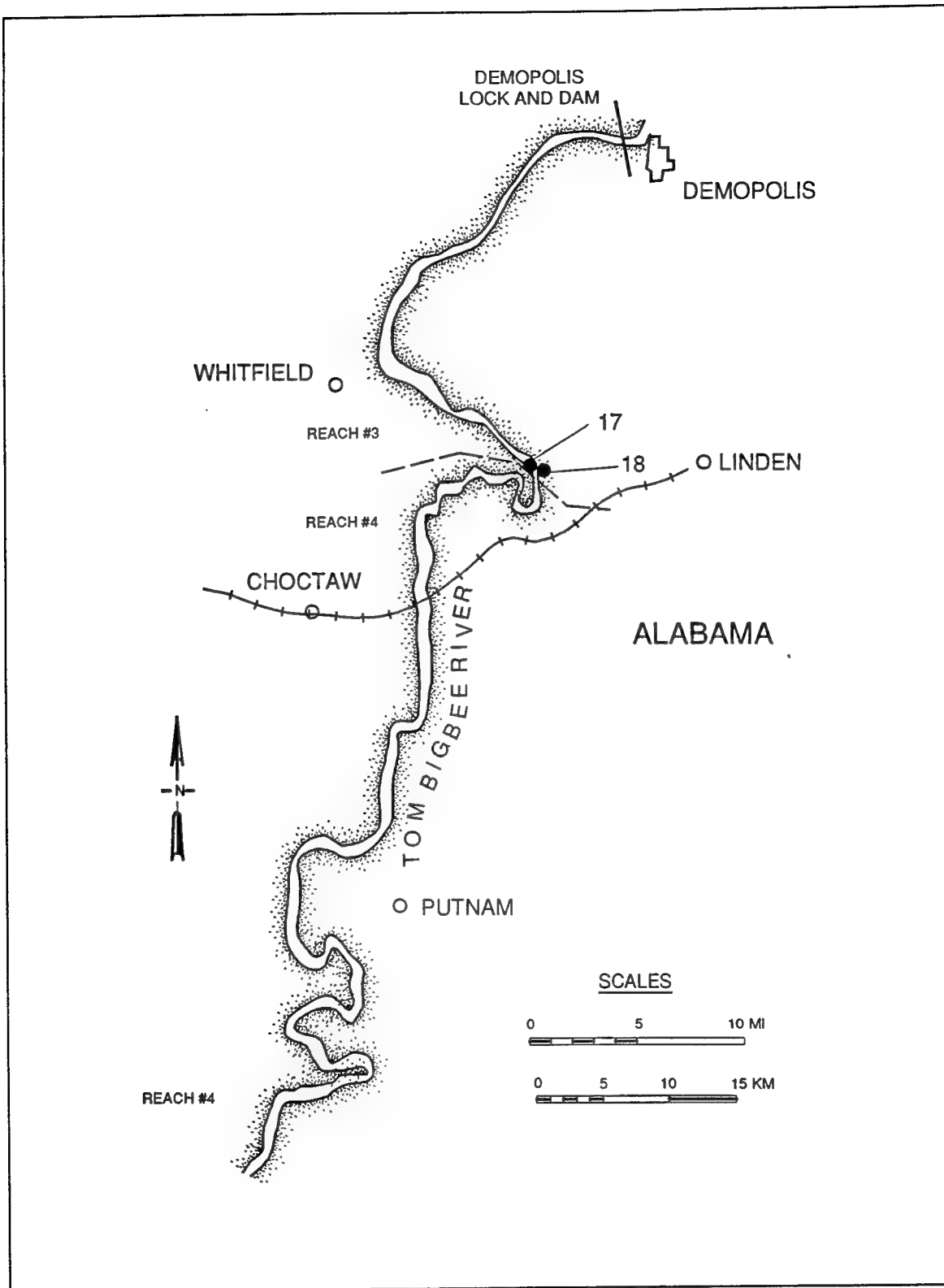


Figure 3. Location of disposal areas 17-18, Tombigbee River, Alabama

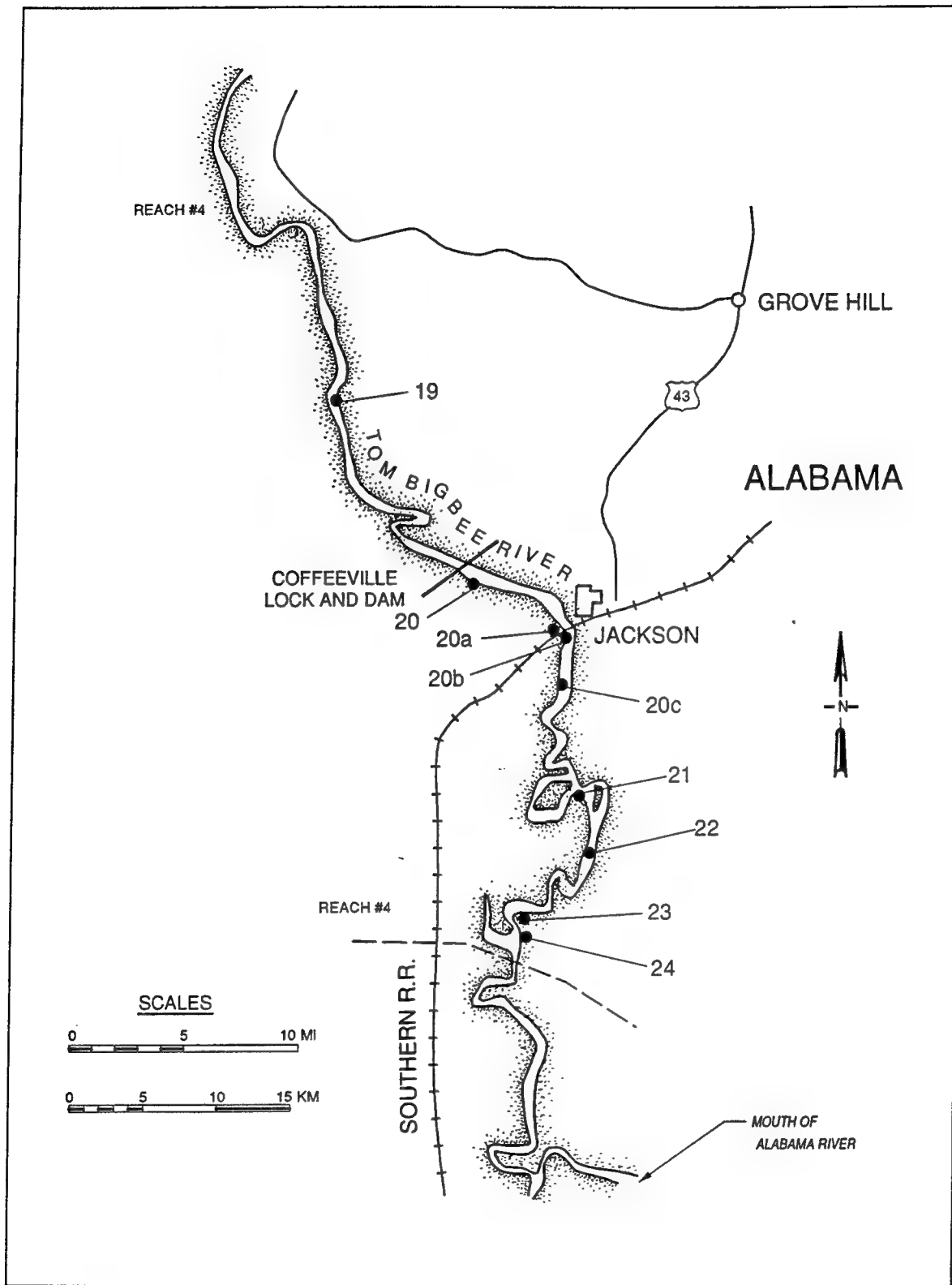


Figure 4. Location of disposal areas 19-24, Tombigbee River, Alabama

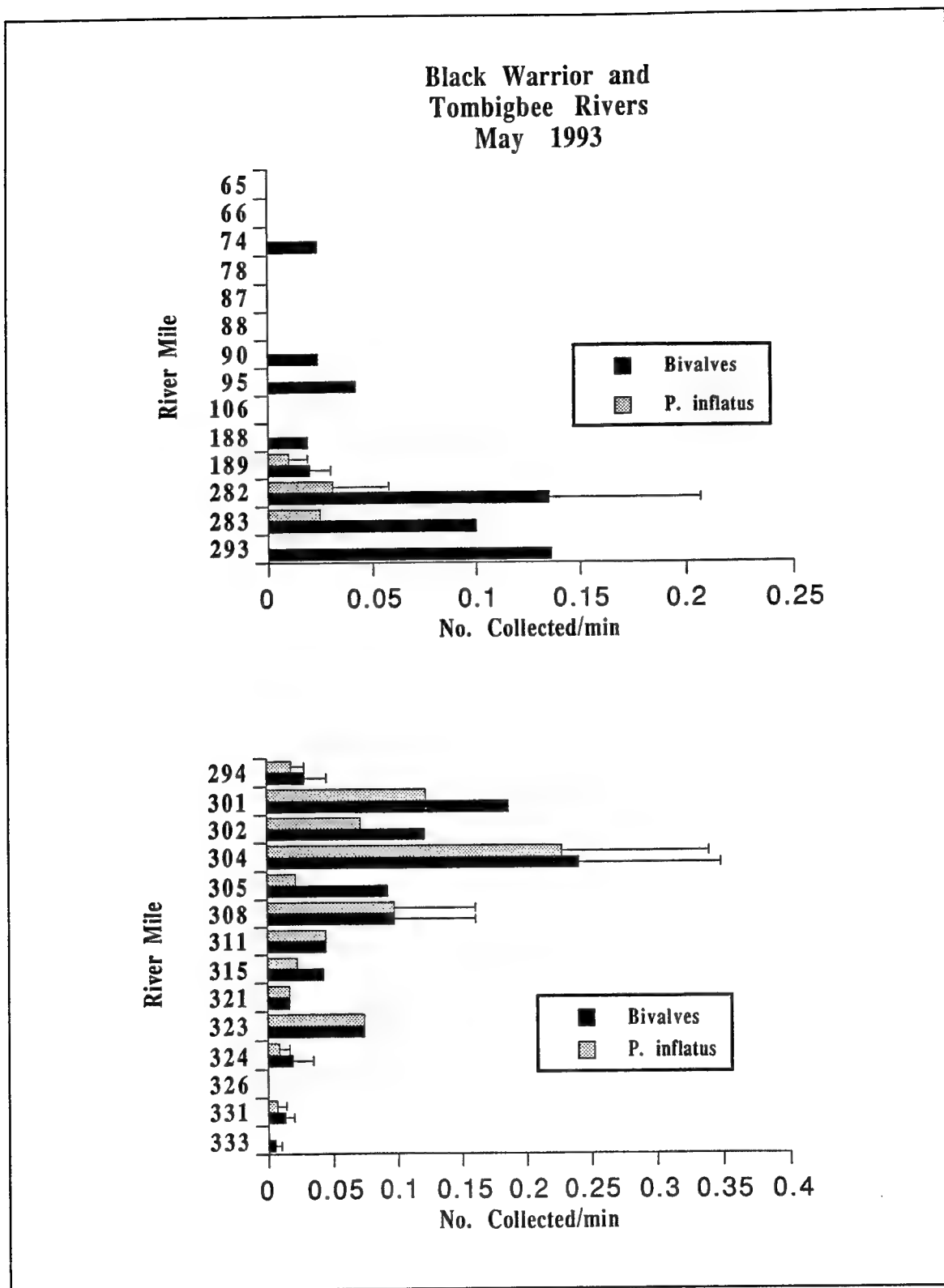


Figure 5. Total density (organisms/100 sq m) of *P. inflatus* and all other bivalves (native mussels as well as the Asian clam *Corbicula fluminea*) at disposal areas in the Black Warrior and Tombigbee rivers, Alabama, 19-24 May 1993

Black Warrior and  
Tombigbee Rivers  
May 1993

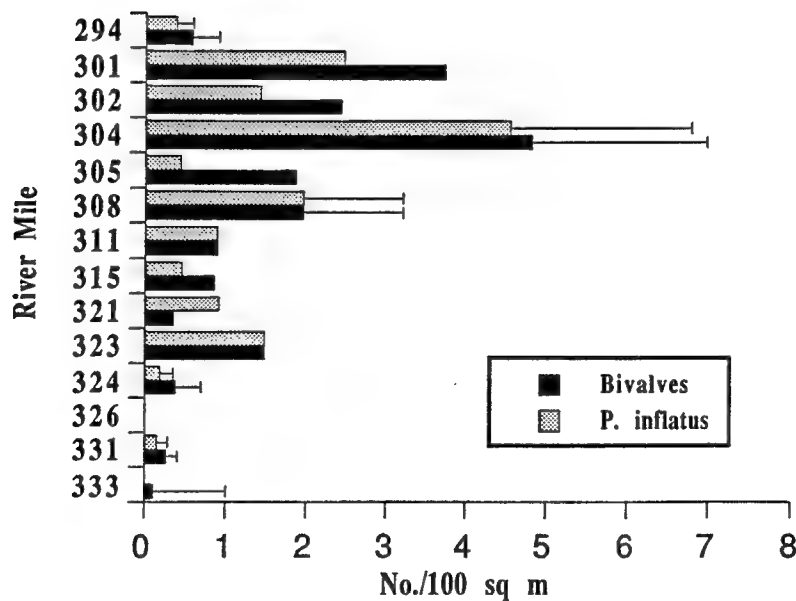
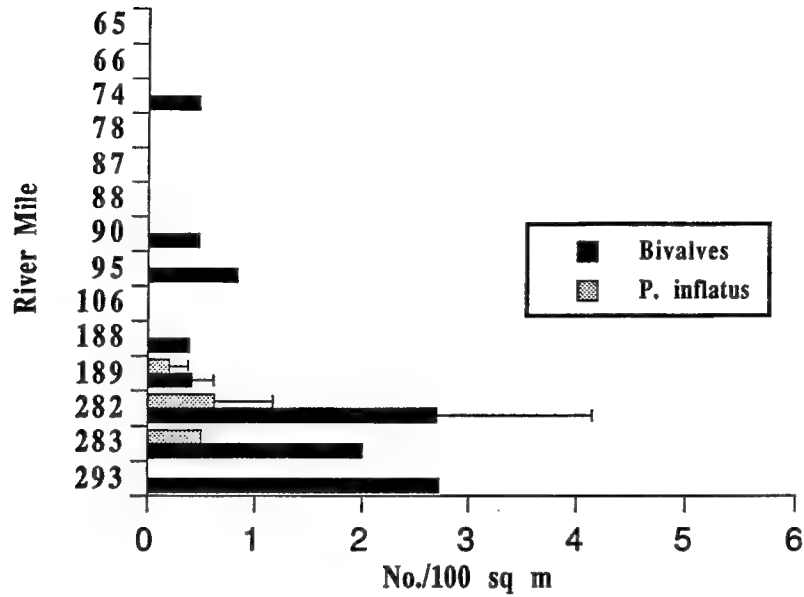


Figure 6. Number of *P. inflatus* and total bivalves (native mussels as well as the Asian clam *Corbicula fluminea*) collected/minute at disposal areas in the Black Warrior and Tombigbee rivers, Alabama, 19-24 May 1993

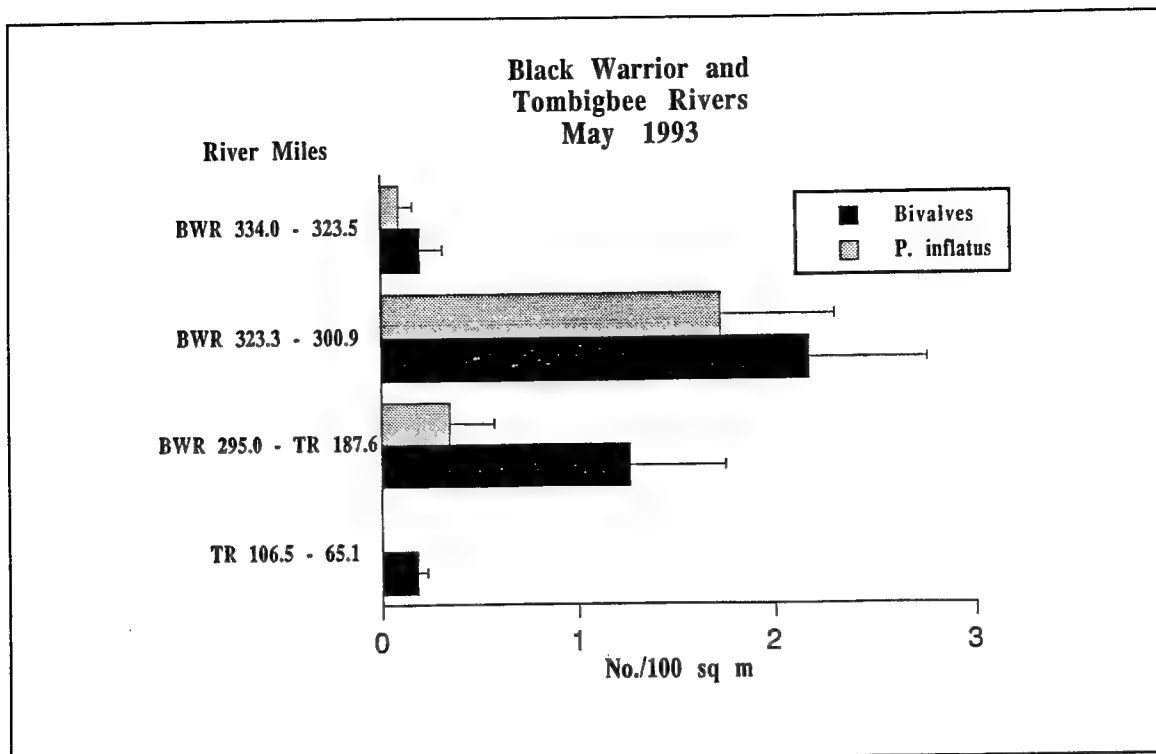


Figure 7. Total density (organisms/100 sq m) of *P. inflatus* and all other bivalves (native mussels as well as the Asian clam *Corbicula fluminea*) at major reaches of the Black Warrior and Tombigbee rivers, Alabama, 19-24 May 1993

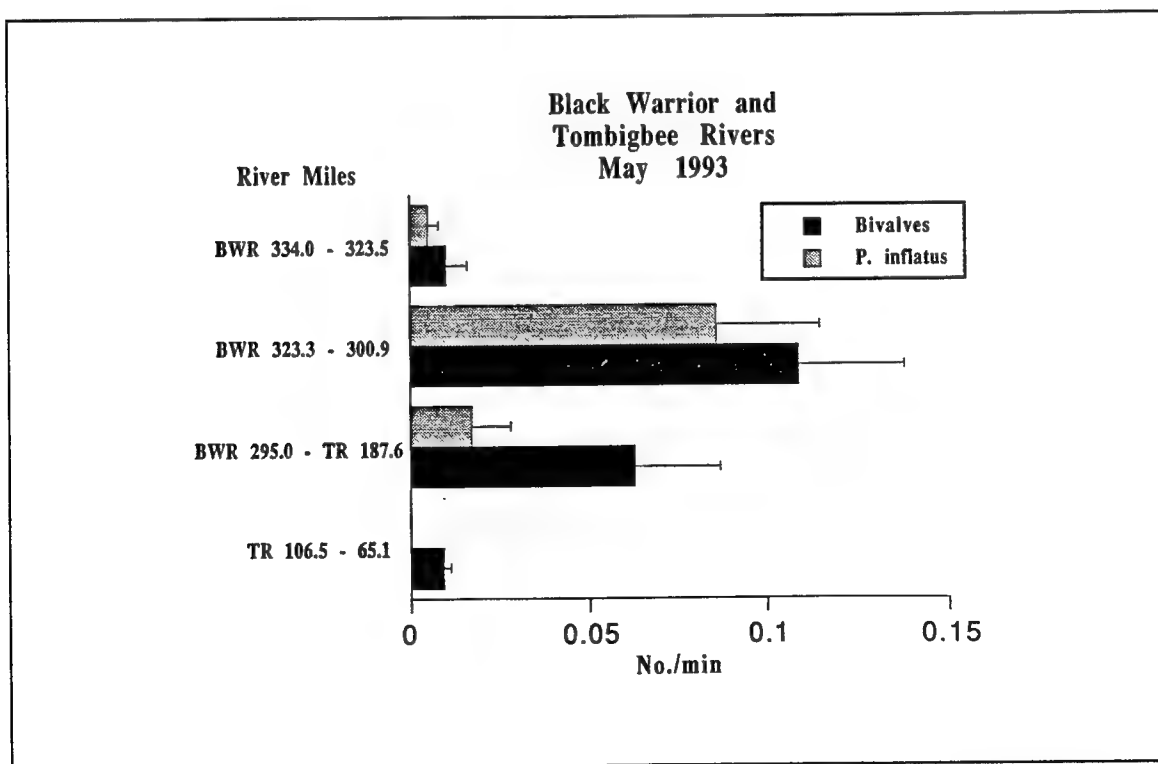


Figure 8. Number of *P. inflatus* and total bivalves (native mussels as well as the Asian clam *Corbicula fluminea*) collected/minute at major reaches of the Black Warrior and Tombigbee rivers, Alabama, 19-24 May 1993

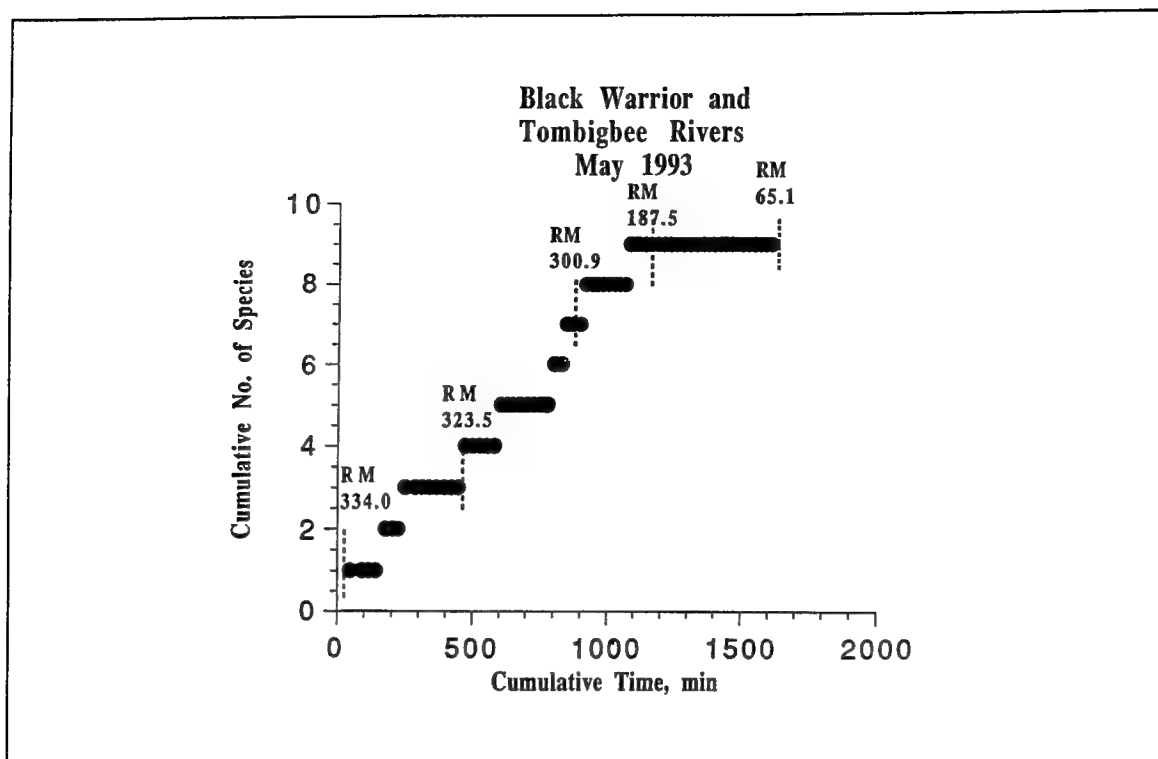


Figure 9. Relationship between cumulative number of minutes expended by divers searching for bivalves versus number of species collected. Data are sorted by river mile; i.e., the most upriver site (RM 334.0) is at 0 min, and the most downriver site (RM 65.1) is just past 1,600 min

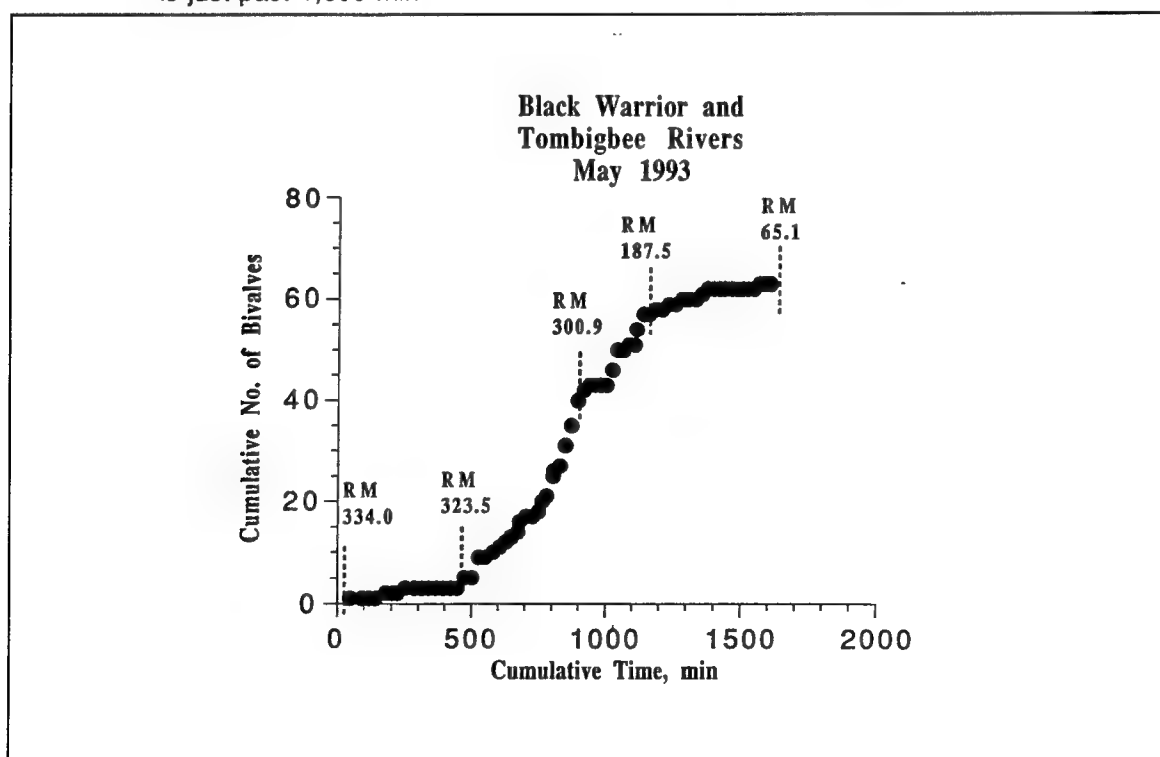


Figure 10. Relationship between cumulative number of minutes expended by divers searching for bivalves versus cumulative number of bivalves collected. Data are sorted by river mile; i.e., the most upriver site (RM 334.0) is at 0 min, and the most downriver site (RM 65.1) is just past 1,600 min

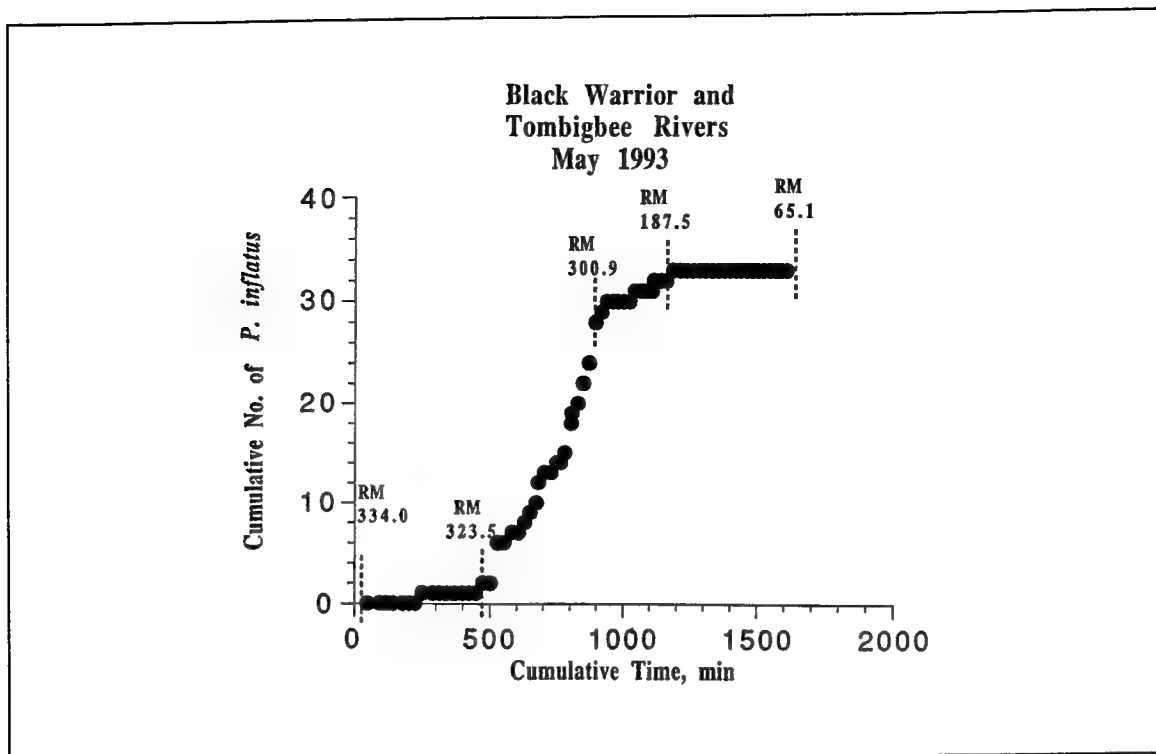


Figure 11. Relationship between cumulative number of minutes expended by divers searching for bivalves versus cumulative number of *Potamilus inflatus* collected. Data are sorted by river mile; i.e., the most upriver site (RM 334.0) is at 0 min, and the most downriver site (RM 65.1) is just past 1,600 min

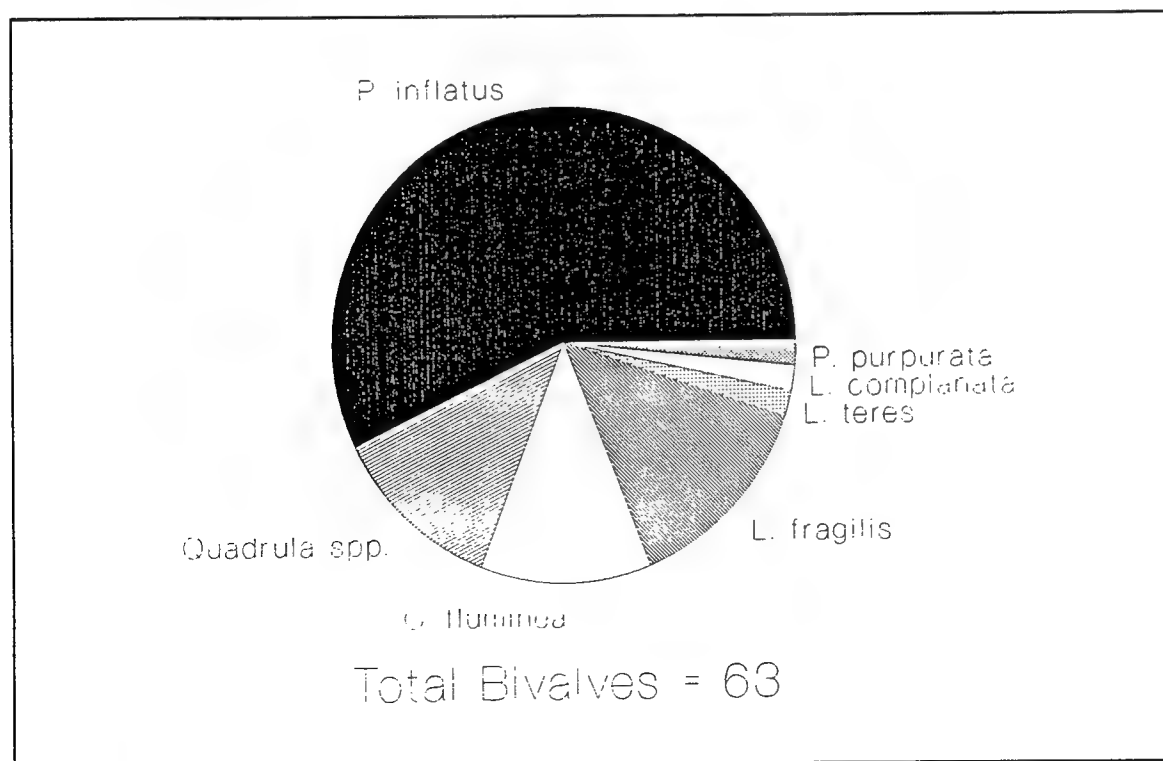
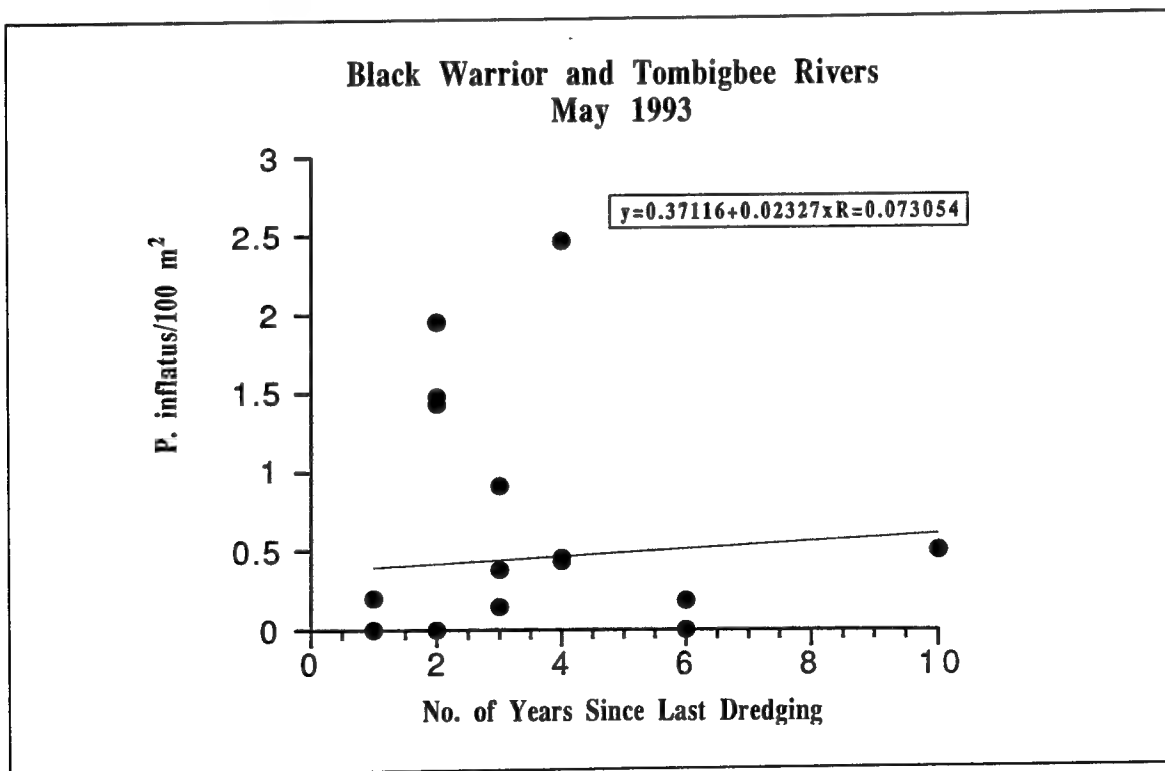
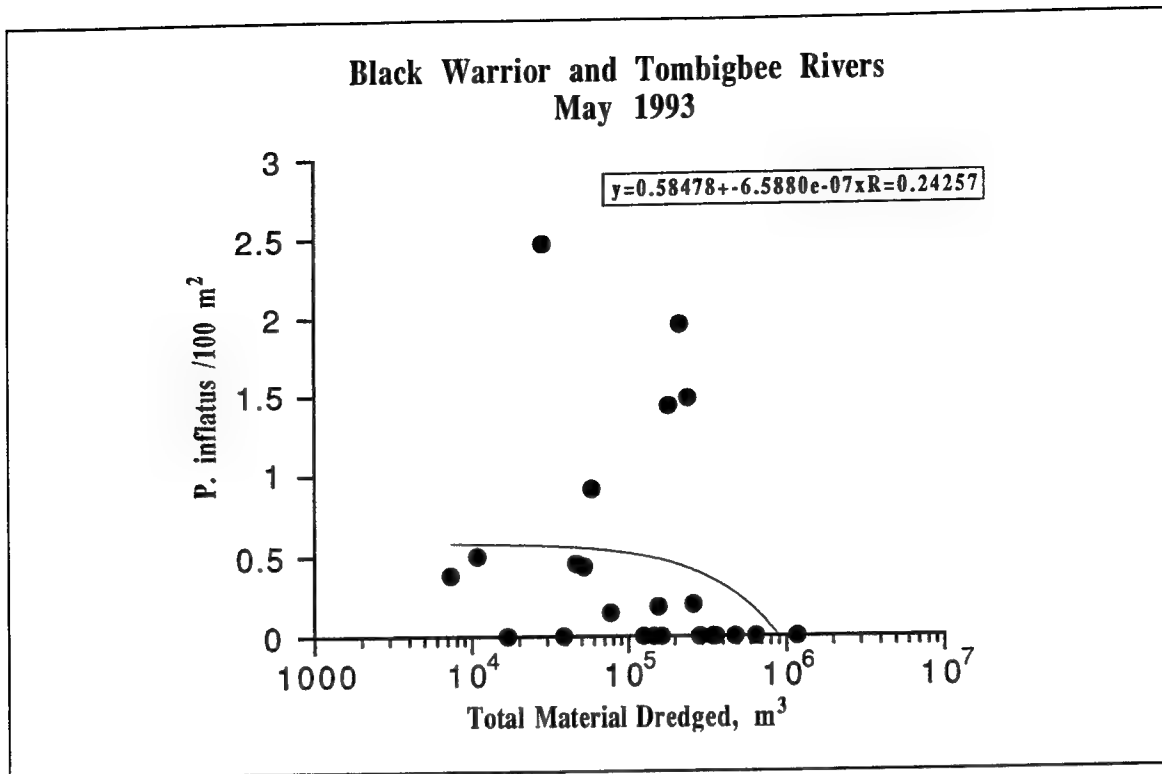


Figure 12. Percent abundance of each species (and the genus *Quadrula*) collected in the Black Warrior and Tombigbee rivers, Alabama, 19-24 May 1993



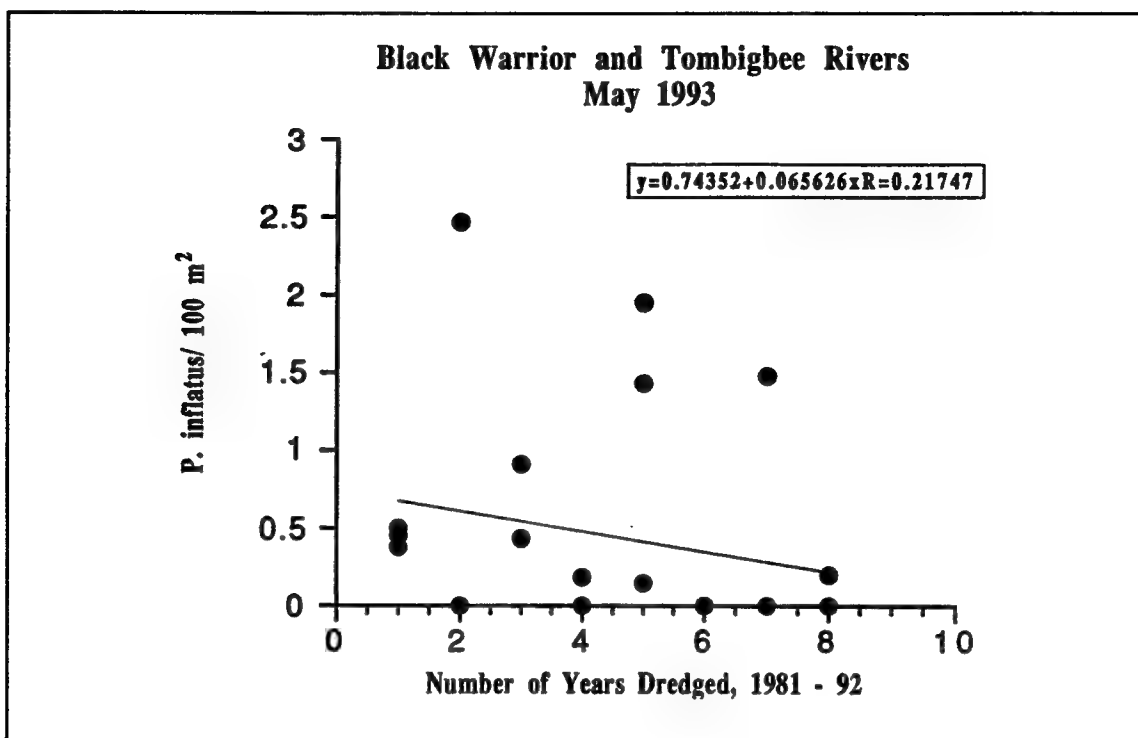


Figure 15. Relationship between *P. inflatus* density (number/100 sq m) and number of years that dredging occurred between 1981 and 1992 at selected disposal areas in the Black Warrior and Tombigbee rivers, Alabama

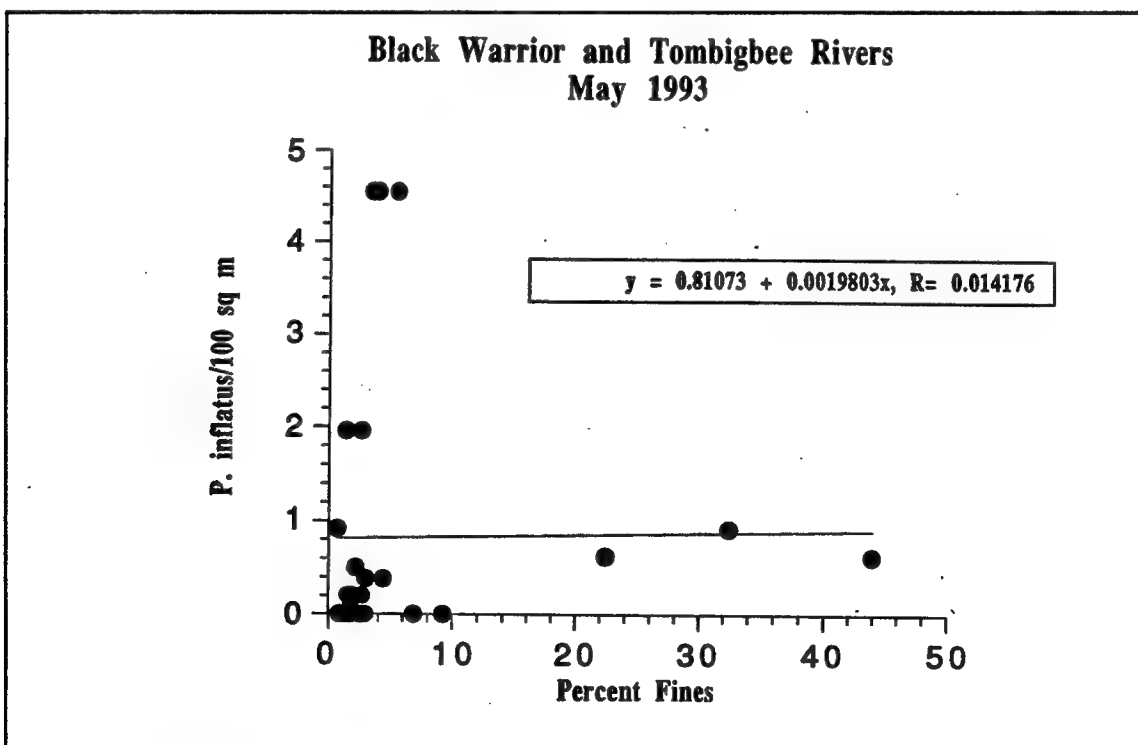


Figure 16. Relationship between percent fines in sediment samples (particles less than 0.08 mm in diameter) and density of *P. inflatus* (number of individuals/100 sq m) at selected disposal areas in the Black Warrior and Tombigbee rivers, Alabama

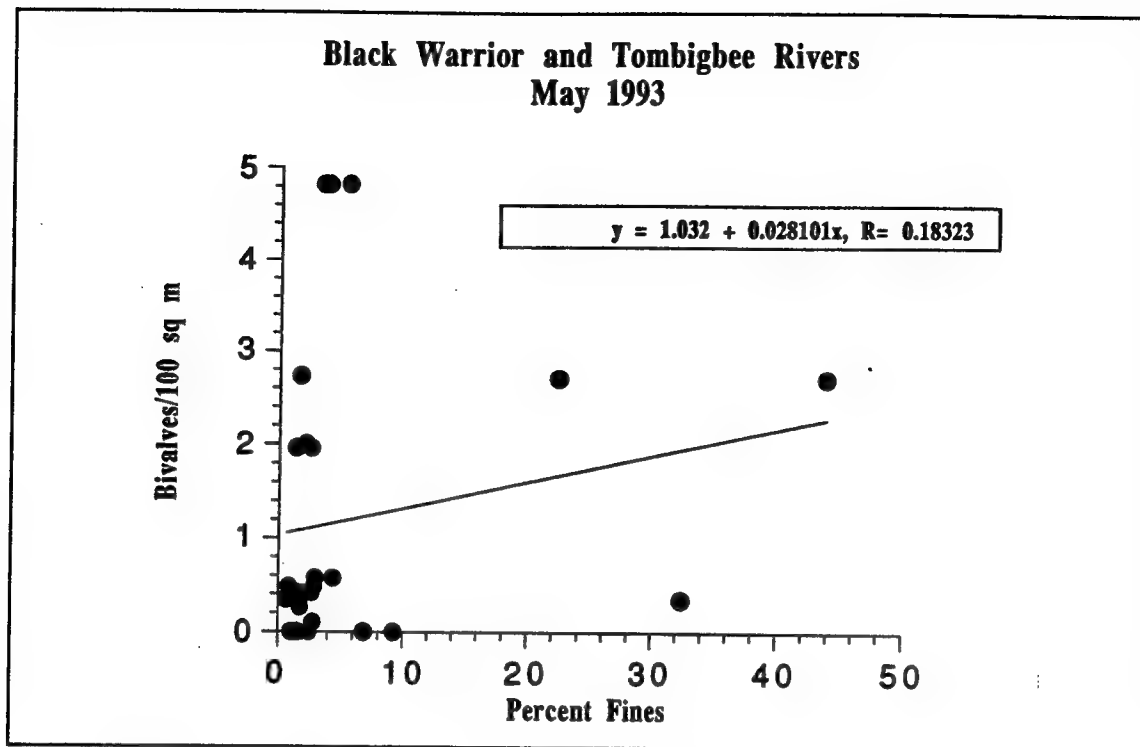


Figure 17. Relationship between percent fines in sediment samples (particles less than 0.08 mm in diameter) and total bivalve density (number of individuals collected/minute) at selected disposal areas in the Black Warrior and Tombigbee rivers, Alabama

**Table 1**  
**Grain Size Distribution for Sediments Collected at Selected Dredged**  
**Material Disposal Areas Along the Black Warrior and Tombigbee**  
**Rivers, Alabama, 19-24 May 1993**

Disposal Area	Replicate No.	Percent Gravel	Percent Sand	Percent Fines
1	1	0.1	97.1	2.8
2	4	0.3	97.8	1.8
3	3	0.1	97.4	2.5
4	4	0.6	97.4	1.9
6	1	0.0	67.5	32.5
6	2	0.0	99.3	0.7
8	2	0.0	97.4	2.6
8	2	0.0	98.6	1.4
10	1	4.3	92.2	3.5
10	1	0.0	94.5	5.5
10	2	1.3	94.8	3.9
13	1	0.0	95.6	4.4
13	3	1.4	95.6	3.0
14	1	0.9	97.4	1.7
15	1	0.0	97.8	2.2
16	1	0.0	77.5	22.5
16	3	0.0	56.0	44.0
17	1	0.0	97.3	2.7
17	2	0.0	98.1	1.9
17	3	0.0	98.3	1.7
17	4	0.0	98.4	1.6
20.4	1	0.1	96.9	2.9
20.4	2	0.0	98.9	1.1
20.6	1	0.0	93.1	6.9
21	1	0.4	98.1	1.5
21	2	36.7	61.7	1.6

(Continued)

Note: See Figures 2-4 for location of disposal areas.  
 Gravel: >5.0 mm; Sand: 0.08 to 5.0 mm; Fines: <0.08 mm.

Table 1 (Concluded)				
Disposal Area	Replicate No.	Percent Gravel	Percent Sand	Percent Fines
22	1	1.0	98.1	0.9
24	1	0.0	90.7	9.3
Average		1.69	92.27	6.04
Minimum		0.00	56.00	0.70
Maximum		36.70	99.30	44.00

**Table 2**  
**Percent Moisture and Percent Organic Content of Sediments**  
**Collected at Selected Dredged Material Disposal Areas, Black**  
**Warrior and Tombigbee Rivers, Alabama, 18-24 May 1993**

Disposal Area	Site	Moisture, %	Organic, %
1	1	21.42	2.55
2	4	19.59	2.51
3	3	21.17	2.56
4	4	19.94	2.85
6	1	20.91	2.45
6	2	20.97	2.83
8	2	21.13	2.20
10	1	21.66	2.36
10	2	20.74	2.53
13	1	21.22	2.72
13	3	19.53	2.81
14	1	20.00	2.66
15	1	21.27	3.00
16	1	25.46	2.04
16	3	35.09	2.88
17	1	18.60	2.56
17	2	20.71	3.12
17	3	22.48	2.83
17	4	19.47	2.91
20a	1	19.54	2.45
20b	2	18.33	2.27
20c	1	20.58	2.24
21	1	19.32	2.40
21	2	11.77	1.81
22	1	18.05	2.11
24	1	21.67	2.65
Average		20.79	2.55
Minimum		11.77	1.81
Maximum		35.09	3.12

Note: See Figures 2-4 for location of disposal areas.

**Table 3****Summary Statistics for Freshwater Bivalves Collected at 28 Dredged Material Disposal Areas Along the Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Description	Disposal Area	River Mile	Total Area sq m	Total Time min	Bivalves/min	P. Inflatus/ min	Bivalves/ 100 sq m	P. Inflatus/ 100 sq m
Potato Creek	1	333	715	143	0.005	0.000	0.104	0.000
Clements Bend	2	331	725	145	0.013	0.007	0.259	0.148
Robinson Bend	3	326	400	80	0.000	0.000	0.000	0.000
North Star Wreck	4	324	535	107	0.019	0.009	0.370	0.185
Mile 323 Bar	5	323	255	51	0.074	0.074	1.481	1.481
Fosters Ferry	6	321	280	56	0.017	0.017	0.345	0.913
Eagle Shoals	7	315	235	47	0.043	0.023	0.855	0.455
Kings Mountain	7a	311	225	45	0.045	0.045	0.893	0.893
Hulls Bar	8	308	270	54	0.098	0.098	1.957	1.957
Van Cleave/Lewis Bar	9	305	185	37	0.093	0.022	1.863	0.435
McGowin Bluff	10	304	215	43	0.241	0.228	4.817	4.550
Mud Bar	11	302	215	43	0.122	0.072	2.435	1.435

*(Continued)*

Note: See Figures 2-4 for location of disposal areas.

**Table 3 (Concluded)**

Description	Disposal Area	River Mile	Total Area sq m	Total Time min	Bivalves/min	P. Inflatus/ min	Bivalves/ 100 sq m	P. Inflatus/ 100 sq m
Wildhorse Bar	12	301	240	48	0.187	0.123	3.739	2.470
Izzard Shoals	13	294	525	105	0.029	0.019	0.571	0.381
Old Lock No. 9	14	293	110	22	0.136	0.000	2.727	0.000
Mary H. Bar	15	283	205	41	0.100	0.025	2.000	0.500
Morrows Rock	16	282	375	75	0.135	0.031	2.702	0.625
Smiths Island	17	189	470	94	0.020	0.010	0.408	0.200
Rainwater Bar	18	188	245	49	0.019	0.000	0.385	0.000
Waites Landing	19	106	245	49	0.000	0.000	0.000	0.000
St. Elmo Bar	20	95	120	24	0.042	0.000	0.833	0.000
Ala. Elec. Co-op	20a	90	205	41	0.024	0.000	0.476	0.000
Blackwell's Bar	20b	88	205	41	0.000	0.000	0.000	0.000
East Bassetts Bar	20c	87	120	24	0.000	0.000	0.000	0.000
Sunflower Cut-off Bar	21	78	305	61	0.000	0.000	0.000	0.000
Batchelors	22	74	220	44	0.024	0.000	0.476	0.000
Green Lake	23	66	100	20	0.000	0.000	0.000	0.000
Side Lake Bayou	24	65	105	21	0.000	0.000	0.000	0.000

**Table 4****Standard Error of the Mean for Freshwater Bivalves at 28 Dredged Material Disposal Areas Along the Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Description	Disposal Area	River Mile	Total Area sq m	Total Time min	Bivalves/min	<i>P. Inflatus</i> /min	Bivalves/100 sq m	<i>P. Inflatus</i> /100 sq m
Potato Creek	1	333	715	143	0.005	0.000	0.090	0.000
Clements Bend	2	331	725	145	0.007	0.007	0.144	0.133
Robinson Bend	3	326	400	80	0.000	0.000	0.000	0.000
North Star Wreck	4	324	535	107	0.016	0.008	0.321	0.160
Mile 323 Bar	5	323	255	51	0.000	0.000	0.000	0.000
Fosters Ferry	6	321	280	56	0.000	0.000	0.000	0.000
Eagle Shoals	7	315	235	47	0.000	0.000	0.000	0.000
Kings Mountain	7a	311	225	45	0.000	0.000	0.000	0.000
Hulls Bar	8	308	270	54	0.063	0.063	1.259	1.259
Van Cleave/Lewis Bar	9	305	185	37	0.000	0.000	0.000	0.000
McGowin Bluff	10	304	215	43	0.108	0.112	2.165	2.241
Mud Bar	11	302	215	43	0.000	0.000	0.000	0.000

**(Continued)**

Note: See Figures 2-4 for location of disposal areas.

Table 4 (Concluded)

Description	Disposal Area	River Mile	Total Area sq m	Total Time min	Bivalves/ min	P. Inflatus/ min	Bivalves/ 100 sq m	P. Inflatus/ 100 sq m
Wildhorse Bar	12	301	240	48	0.000	0.000	0.000	0.000
Izzard Shoals	13	294	525	105	0.017	0.010	0.341	0.209
Old Lock No. 9	14	293	110	22	0.000	0.000	0.000	0.000
Mary H. Bar	15	283	205	41	0.000	0.000	0.000	0.000
Morrows Rock	16	282	375	75	0.072	0.027	1.444	0.541
Smiths Island	17	189	470	94	0.010	0.009	0.204	0.173
Rainwater Bar	18	188	245	49	0.000	0.000	0.000	0.000
Waites Landing	19	106	245	49	0.000	0.000	0.000	0.000
St. Elmo Bar	20	95	120	24	0.000	0.000	0.000	0.000
Ala. Elec. Co-op	20a	90	205	41	0.000	0.000	0.000	0.000
Blackwell's Bar	20b	88	205	41	0.000	0.000	0.000	0.000
East Bassetts Bar	20c	87	120	24	0.000	0.000	0.000	0.000
Sunflower Cut-off Bar	21	78	305	61	0.000	0.000	0.000	0.000
Batchelors	22	74	220	44	0.000	0.000	0.000	0.000
Green Lake	23	66	100	20	0.000	0.000	0.000	0.000
Side Lake Bayou	24	65	105	21	0.000	0.000	0.000	0.000

**Table 5**  
**Summary Statistics for Freshwater Bivalves Collected at**  
**Dredged Material Disposal Areas in Four Reaches of the Black**  
**Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

	Bivalves/ min	<i>P. inflatus</i> / min	Bivalves/ 100 sq m	<i>P. inflatus</i> / 100 sq m
<b>RM 334.0 - 323.5</b>				
Mean	0.010	0.005	0.200	0.093
SE	0.006	0.003	0.113	0.069
No. of samples	16			
<b>RM 323.3 - 300.9</b>				
Mean	0.109	0.086	2.177	1.727
SE	0.029	0.029	0.582	0.577
No. of samples	20			
<b>RM 295.0 - 187.6</b>				
Mean	0.069	0.019	1.377	0.388
SE	0.024	0.011	0.485	0.226
No. of samples	16			
<b>RM 107.0 - 65.4</b>				
Mean	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000
No. of samples	17			
Note: SE = standard error of the mean.				

**Table 6**  
**Percent Abundance and Percent Occurrence for Bivalves**  
**Collected at Dredged Material Disposal Areas Along the Black**  
**Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Species	Percent Species Abundance	Percent Occurrence	
		Disposal Areas	Total Dives
<i>Potamilus inflatus</i>	52.4	53.6	31.8
<i>Leptodea fragilis</i>	12.7	25.0	11.6
<i>Corbicula fluminea</i>	11.1	10.7	4.3
<i>Obliquaria reflexa</i>	7.9	14.3	7.2
<i>Quadrula rumphiana</i>	1.6	3.6	1.4
<i>Quadrula apiculata</i> complex	9.5	21.4	8.7
<i>Lampsilis teres</i>	1.6	3.6	1.4
<i>Lasmigonia complanata</i>	1.6	3.6	1.4
<i>Potamilus purpurata</i>	1.6	3.6	1.4
Total	63	28	69
Note: A total of 63 mussels were collected at 28 disposal sites in 69 separate dives.			

**Table 7**  
**Estimate of Total Area Present at Each of 28 Dredged Material Disposal Areas Along the Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Disposal Area <sup>1</sup>	River	Description	River Bank	Upriver Point	Downriver Point	Total Miles	Linear Distance m	Estimated Area <sup>2</sup> sq m
1	BW	Potato Creek	LDB	334.0	333.2	0.8	1,287.4	25,748.8
1	BW	Potato Creek	RDB	333.1	332.8	0.3	482.8	9,655.8
2	BW	Clements Bend	RDB	332.6	331.2	1.4	2,253.0	45,060.4
3	BW	Robinson Bend	RDB	326.5	325.4	1.1	1,770.2	35,404.6
4	BW	North Star Wreck	LDB	325.6	325.0	0.6	965.6	19,311.6
4	BW	North Star Wreck	RDB	324.8	323.9	0.9	1,448.4	28,967.4
4	BW	North Star Wreck	LDB	323.9	323.5	0.4	643.7	12,874.4
5	BW	Mile 323 Bar	LDB	323.3	322.5	0.8	1,287.4	25,748.8
6	BW	Fosters Ferry	LDB	322.1	321.6	0.5	804.7	16,093.0
6	BW	Fosters Ferry	LDB	321.4	321.1	0.3	482.8	9,655.8
7	BW	Eagle Shoals	LDB	315.3	314.7	0.6	965.6	19,311.6

(Sheet 1 of 4)

Note: BW = Black Warrior River; T = Tombigbee River; LDB = Left Descending Bank; RDB = Right Descending Bank.

<sup>1</sup> See Figures 2-4 for location of disposal areas.

<sup>2</sup> "Estimated Area" values are based on the assumption that a 20-m-wide section at each disposal area is suitable for bivalves.

Table 7 (Continued)

Disposal Area <sup>1</sup>	River	Description	River Bank	Upriver Point	Downriver Point	Total Miles	Linear Distance m	Estimated Area <sup>2</sup> sq m
7a	BW	Kings Mountain	RDB	312.3	311.3	1.0	1,609.3	32,186.0
8	BW	Hulls Bar	RDB	310.1	308.9	1.2	1,931.2	38,623.2
8	BW	Hulls Bar	LDB	309.1	308.5	0.6	965.6	19,311.6
8	BW	Hulls Bar	RDB	308.7	308.5	0.2	321.9	6,437.2
8	BW	Hulls Bar	RDB	308.3	307.8	0.5	804.7	16,093.0
9	BW	Van Cleave/Lewis Bar	LDB	305.9	305.6	0.3	482.8	9,655.8
9	BW	Van Cleave/Lewis Bar	RDB	305.6	305.1	0.5	804.7	16,093.0
10	BW	McGowin Bluff	LDB	305.0	304.4	0.6	965.6	19,311.6
10	BW	McGowin Bluff	RDB	304.4	303.3	1.1	1,770.2	35,404.6
11	BW	Mud Bar	RDB	302.7	302.1	0.6	965.6	19,311.6
12	BW	Wildhorse Bar	LDB	302.1	300.9	1.2	1,931.2	38,623.2
13	BW	Izzard Shoals	RDB	295.0	294.8	0.2	321.9	6,437.2
13	BW	Izzard Shoals	LDB	294.7	294.5	0.2	321.9	6,437.2
13	BW	Izzard Shoals	RDB	294.5	294.2	0.3	482.8	9,655.8
13	BW	Izzard Shoals	LDB	294.2	293.7	0.5	804.7	16,093.0

(Sheet 2 of 4)

**Table 7 (Continued)**

Disposal Area <sup>1</sup>	River	Description	River Bank	Upriver Point	Downriver Point	Total Miles	Linear Distance m	Estimated Area <sup>2</sup> sq m
14	BW	Old Lock No. 9	RDB	293.8	293.0	0.8	1,287.4	25,748.8
15	BW	Mary H. Bar	LDB	283.4	283.0	0.4	643.7	12,874.4
15	BW	Mary H. Bar	RDB	283.0	282.5	0.5	804.7	16,093.0
16	BW	Morrows Rock	LDB	282.3	281.8	0.5	804.7	16,093.0
16	BW	Morrows Rock	RDB	282.0	281.8	0.2	321.9	6,437.2
16	BW	Morrows Rock	LDB	281.4	281.2	0.2	321.9	6,437.2
17	T	Smiths Island	LDB	189.6	188.9	0.7	1,126.5	22,530.2
17	T	Smiths Island	RDB	189.2	187.9	1.3	2,092.1	41,841.8
18	T	Rainwater Bar	LDB	188.3	187.6	0.7	1,126.5	22,530.2
19	T	Waites Landing	LDB	107.0	106.5	0.5	804.7	16,093.0
19	T	Waites Landing	RDB	106.5	106.0	0.5	804.7	16,093.0
20	T	St. Elmo Bar	RDB	95.5	95.0	0.5	804.7	16,093.0
20a	T	Ala. Elec. Co-op	RDB	90.9	90.0	0.9	1,448.4	28,967.4
20b	T	Blackwell's Bar	RDB	89.1	88	1.1	1,770.2	35,404.6
20b	T	Blackwell's Bar	LDB	88.4	87.4	1.0	1,609.3	32,186.0

(Sheet 3 of 4)

**Table 7 (Concluded)**

Disposal Area'	River	Description	River Bank	Upriver Point	Downriver Point	Total Miles	Linear Distance m	Estimated Area <sup>2</sup> sq m
20c	T	East Bassetts Bar	LDB	87.3	86.7	0.6	965.6	19,311.6
20c	T	East Bassetts Bar	RDB	86.8	85.3	1.5	2,414.0	48,279.0
21	T	Sunflower Cut-off Bar	RDB	78.5	77.9	0.6	965.6	19,311.6
21	T	Sunflower Cut-off Bar	RDB	77.7	77.3	0.4	643.7	12,874.4
21	T	Sunflower Cut-off Bar	LDB	77.4	77.0	0.4	643.7	12,874.4
22	T	Lower Batchelors	RDB	76.5	74.4	2.1	3,379.5	67,590.6
22	T	Upper Batchelors	LDB	74.7	74.0	0.7	1,126.5	22,530.2
23	T	Green Lake	LDB	67.0	65.5	1.5	2,414.0	48,279.0
24	T	Side Lake Bayou	LDB	65.5	65.1	0.4	643.7	12,874.4
Total						34.7	55,842.7	1,116,854.2

(Sheet 4 of 4)

**Table 8**  
**Estimate of Total Number of *P. Inflatus* at Each Dredged Material Disposal Area and Estimate of Total Time Required to Recover All *P. Inflatus*, Based on Collecting Rate, Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Disposal Area <sup>1</sup>	River	Description	Side	Estimated <i>P. Inflatus</i> Density No./100 sq m	Estimated No. of <i>P. Inflatus</i> Present	Estimated <i>P. Inflatus</i> Collected/ min	Estimated Time to Collect all <i>P. Inflatus</i> hr
1	BW	Potato Creek	LDB	0.000	0.0	0.000	0.0
1	BW	Potato Creek	RDB	0.000	0.0	0.000	0.0
2	BW	Clements Bend	RDB	0.148	66.7	0.007	158.8
3	BW	Robinson Bend	RDB	0.000	0.0	0.000	0.0
4	BW	North Star Wreck	LDB	0.185	35.7	0.009	66.2
4	BW	North Star Wreck	RDB	0.185	53.6	0.009	99.2
4	BW	North Star Wreck	LDB	0.185	23.8	0.009	44.1
5	BW	Mile 323 Bar	LDB	1.481	381.3	0.074	85.9
6	BW	Fosters Ferry	LDB	0.913	146.9	0.017	144.0
6	BW	Fosters Ferry	LDB	0.913	88.2	0.017	86.4

(Sheet 1 of 5)

Note: See Table 7 for estimates of the total available habitat (in square meters) for bivalves at each disposal area. BW = Black Warrior River; T = Tombigbee River.  
LDB = Left Descending Bank; RDB = Right Descending Bank.  
<sup>1</sup> See Figures 2-4 for location of disposal areas.

**Table 8 (Continued)**

Disposal Area <sup>1</sup>	River	Description	Side	Estimated <i>P. inflatus</i> Density No./100 sq m	Estimated No. of <i>P. inflatus</i> Present	Estimated <i>P. inflatus</i> Collected/ min	Estimated Time to Collect all <i>P. inflatus</i> hr
7	BW	Eagle Shoals	LDB	0.455	87.9	0.023	63.7
7a	BW	Kings Mountain	RDB	0.893	287.4	0.045	106.5
8	BW	Hulls Bar	RDB	1.957	755.9	0.098	128.5
8	BW	Hulls Bar	LDB	1.957	377.9	0.098	64.3
8	BW	Hulls Bar	RDB	1.957	126.0	0.098	21.4
8	BW	Hulls Bar	RDB	1.957	314.9	0.098	53.6
9	BW	Van Cleave/Lewis Bar	LDB	0.435	42.0	0.022	31.8
9	BW	Van Cleave/Lewis Bar	RDB	0.435	70.0	0.022	53.0
10	BW	McGowin Bluff	LDB	4.550	878.7	0.228	64.2
10	BW	McGowin Bluff	RDB	4.550	1,610.9	0.228	117.8
11	BW	Mud Bar	RDB	1.435	277.1	0.072	64.1
12	BW	Wildhorse Bar	LDB	2.470	954.0	0.123	129.3
13	BW	Izzard Shoals	RDB	0.381	24.5	0.019	21.5

(Sheet 2 of 5)

**Table 8 (Continued)**

Disposal Area <sup>1</sup>	River	Description	Side	Estimated <i>P. Inflatus</i> Density No./100 sq m	Estimated No. of <i>P. Inflatus</i> Present	Estimated <i>P. Inflatus</i> Collected/ min	Estimated Time to Collect all <i>P. Inflatus</i> hr
13	BW	Izzard Shoals	LDB	0.381	24.5	0.019	21.5
13	BW	Izzard Shoals	RDB	0.381	36.8	0.019	32.3
13	BW	Izzard Shoals	LDB	0.381	61.3	0.019	53.8
14	BW	Old Lock No. 9	RDB	0.000	0.0	0.000	0.0
15	BW	Mary H. Bar	LDB	0.500	64.4	0.025	42.9
15	BW	Mary H. Bar	RDB	0.500	80.5	0.025	53.6
16	BW	Morrows Rock	LDB	0.625	100.6	0.031	54.1
16	BW	Morrows Rock	RDB	0.625	40.2	0.031	21.6
16	BW	Morrows Rock	LDB	0.625	40.2	0.031	21.6
17	T	Smiths Island	LDB	0.200	45.1	0.010	75.1
17	T	Smiths Island	RDB	0.200	83.7	0.010	139.5
18	T	Rainwater Bar	LDB	0.000	0.0	0.000	0.0
19	T	Waites Landing	LDB	0.000	0.0	0.000	0.0

(Sheet 3 of 5)

Table 8 (Continued)

Disposal Area <sup>1</sup>	River	Description	Side	Estimated <i>P. inflatus</i> Density No./100 sq m	Estimated No. of <i>P. inflatus</i> Present	Estimated <i>P. inflatus</i> Collected/ min	Estimated Time to Collect all <i>P. inflatus</i> hr
19	T	Waites Landing	RDB	0.000	0.0	0.000	0.0
20	T	St. Elmo Bar	RDB	0.000	0.0	0.000	0.0
20a	T	Ala. Elec. Co-op	RDB	0.000	0.0	0.000	0.0
20b	T	Blackwell's Bar	RDB	0.000	0.0	0.000	0.0
20b	T	Blackwell's Bar	LDB	0.000	0.0	0.000	0.0
20c	T	East Bassetts Bar	LDB	0.000	0.0	0.000	0.0
20c	T	East Bassetts Bar	RDB	0.000	0.0	0.000	0.0
21	T	Sunflower Cut-off Bar	RDB	0.000	0.0	0.000	0.0
21	T	Sunflower Cut-off Bar	RDB	0.000	0.0	0.000	0.0
21	T	Sunflower Cut-off Bar	LDB	0.000	0.0	0.000	0.0
22	T	Lower Batchelors	RDB	0.000	0.0	0.000	0.0
22	T	Upper Batchelors	LDB	0.000	0.0	0.000	0.0

(Sheet 4 of 5)

**Table 8 (Concluded)**

Disposal Area <sup>1</sup>	River	Description	Side	Estimated <i>P. inflatus</i> Density No./100 sq m	Estimated No. of <i>P. inflatus</i> Present	Estimated <i>P. inflatus</i> Collected/ min	Estimated Time to Collect all <i>P. inflatus</i> hr
23	T	Green Lake	LDB	0.000	0.0	0.000	0.0
24	T	Side Lake Bayou	LDB	0.000	0.0	0.000	0.0
Total					7,180.7		2,120.4

**(Sheet 5 of 5)**

**Table 9**  
**Total Area Surveyed, Total Time Expended by Two Divers, Total**  
**Size of Disposal Area, and Percent of Total Disposal Area**  
**Searched for Bivalves, Black Warrior and Tombigbee Rivers,**  
**Alabama, 19-24 May 1993**

Description	Disposal Area <sup>1</sup>	River Mile	Total Area sq m	Total Time min	Total Disposal Area sq m	Percent of Area Surveyed
Potato Creek	1	333	715	143	35,405	2.02
Clements Bend	2	331	725	145	45,060	1.61
Robinson Bend	3	326	400	80	35,405	1.13
North Star Wreck	4	324	535	107	61,153	0.87
Mile 323 Bar	5	323	255	51	25,749	0.99
Fosters Ferry	6	321	280	56	25,749	1.09
Eagle Shoals	7	315	235	47	19,312	1.22
Kings Mountain	7a	311	225	45	32,186	0.70
Hulls Bar	8	308	270	54	80,465	0.34
Van Cleave/Lewis Bar	9	305	185	37	25,749	0.72
McGowin Bluff	10	304	215	43	54,716	0.39
Mud Bar	11	302	215	43	19,312	1.11
Wildhorse Bar	12	301	240	48	38,623	0.62
Izzard Shoals	13	294	525	105	38,623	1.36
Old Lock No. 9	14	293	110	22	25,749	0.43
Mary H. Bar	15	283	205	41	28,967	0.71
Morrows Rock	16	282	375	75	28,967	1.29
Smiths Island	17	188	470	94	64,372	0.73
Rainwater Bar	18	188	245	49	22,530	1.09
Waites Landing	19	106	245	49	32,186	0.76
St. Elmo Bar	20	95	120	24	16,093	0.75
Ala. Elec. Co-op	20a	90	205	41	28,967	0.71
Blackwell's Bar	20b	88	205	41	67,591	0.30
East Bassetts Bar	20c	87	120	24	67,591	0.18

(Continued)

<sup>1</sup> See Figures 2-4 for location of disposal areas.

Table 9 (Concluded)						
Description	Disposal Area <sup>1</sup>	River Mile	Total Area sq m	Total Time min	Total Disposal Area sq m	Percent of Area Surveyed
Sunflower Cut-off Bar	21	78	305	61	45,060	0.68
Batchelors	22	74	220	44	90,121	0.24
Green Lake	23	66	100	20	48,279	0.21
Side Lake Bayou	24	65	105	21	12,874	0.82
Total			8,050	1,610	1,116,854	

**Table 10**  
**Summary Information for the Bivalve Survey on the Black**  
**Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Parameter	Value
Total survey time, min	1,610
Total survey time, hr	26.8
Total number of <i>P. inflatus</i> collected	33
Total number of bivalves collected	63
Total area surveyed, sq m	8,050
Total number of sites surveyed	69
Total bivalve density estimate, /sq m	0.008
Total bivalve density estimate, per 100 sq m	0.783

**Table 11**  
**Summary of the Total Material Dredged, Number of Years Since**  
**Last Dredging Cycle, and Total Number of Years Dredged,**  
**1981-92, for Selected Disposal Areas on the Black Warrior and**  
**Tombigbee Rivers, Alabama**

Name of Disposal Area <sup>1</sup>	No.	Total Dredged Material cu m	Time Since Dredging years	Total Years Dredged	River Mile
Potato Creek	1	38,524	6	2	333.3
Clements Bend	2	77,091	3	5	331.1
Robinson Bend	3	146,609	1	6	325.3
Upper North Star Wreck	4	57,055	6	4	324.5
Lower North Star Wreck	4	242,938	2	7	324.5
Foster Ferry	6	58,185	3	3	321.3
Eagle Shoals	7	46,298	4	1	315.1
Hulls Bar, Upper	8	216,755	2	5	309.1
Van Cleave/Lewis	9	51,909	4	3	305.3
Mud Bar	11	183,070	2	5	302.4
Wild Horse Bar	12	28,457	4	2	301.6
Izzard Shoals	13	7,355	3	1	294.4
Mary H. Bar	15	10,857	10	1	282.5
Smiths Island	17	263,528	1	8	188.7
Rainwater Bar	18	125,638	1	7	187.5
Waites Landing	19	288,443	2	7	106.0
St. Elmo Bar	20	645,121	2	7	95.3
Ala. Electric Co-op	20a	16,887	1	2	89.1
Blackwell's Bar	20b	478,894	1	6	87.9
East Bassetts Bar	20c	361,676	2	6	86.7
Sunflower Cut-Off Bar	21	1,169,693	2	8	77.8
Upper Bachelors Landing	22	146,770	6	4	74.6
Lower Bachelors Landing	22	164,260	2	4	73.8
Green Lake	23	348,154	1	7	67.7

<sup>1</sup> See Figures 2-4 for location of disposal areas.

**Table 12**  
**Location, Time Expended Searching by Two Individuals, and Mussels**  
**Collected at Disposal Sites for Small Boat Channels in the Demopolis**  
**Pool of the Black Warrior and Tombigbee Rivers, Alabama, 24 August**  
**1993**

Black Warrior River				
RM	Bank	Time min	Mussels	Mussels/min
227.0	LDB	15	8	0.267
227.3	LDB	10	0	0.000
230.6	RDB	15	8	0.267
231.8	RDB	10	0	0.000
232.0	LDB	15	0	0.000
232.4	LDB	10	0	0.000
Tombigbee River				
219.1	RDB	13	0	0.000
220.9	LDB	30	9	0.150
227.2	LDB	15	0	0.000
227.4	LDB	13	0	0.000
229.7	RDB	10	0	0.000
230.6	RDB	15	0	0.000
231.6	RDB	15	0	0.000
Mussels Collected at Black Warrior River Mile 227.0, LDB				
Scientific Name			Number Collected	
Anodonta grandis			1	
Obliquaria reflexa			1	
Plectomerus dombeyanus			4	
Potamilus inflatus <sup>1</sup>			1	
Quadrula rumphiana			1	
Mussels Collected at Black Warrior River Mile 230.6, RDB				
Plectomerus dombeyanus			7	
Quadrula rumphiana			1	
(Continued)				
Note: LDB = Left Descending Bank; RDB = Right Descending Bank. <sup>1</sup> Shell length = 91.7; Maximum inflation = 33.4.				

Table 12 (Concluded)	
Mussels Collected at Tombigbee River Mile 220.9, LDB	
<i>Lampsilis teres</i>	5
<i>Plectomerus dombeyanus</i>	4
Total mussels collected	25
Total time spent searching	372

# **Appendix A**

## **Summary of Raw Data Collected by Divers**

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**Table A1**  
**Bivalve Sampling Sites at Dredged Material Disposal Areas, Black Warrior**  
**(BW) River and Tombigbee (T) River, 19-24 May 1993**

Dive No.	Date	Description	River	Mile	Bank	Lat	Long
1	19 May 93	Clements Bend	BW	332.6	RDB	33° 11.198	87° 39.826
2	19 May 93	Clements Bend	BW	332.3	RDB	33° 11.296	87° 39.987
3	19 May 93	Clements Bend	BW	332.0	RDB	33° 11.340	87° 40.165
4	19 May 93	Clements Bend	BW	331.4	RDB	33° 11.550	87° 40.520
5	19 May 93	Clements Bend	BW	331.3	RDB	33° 11.603	87° 40.549
6	19 May 93	Potato Creek	BW	333.8	LDB	33° 12.295	87° 39.458
7	19 May 93	Potato Creek	BW	333.5	LDB	33° 12.141	87° 39.596
8	19 May 93	Potato Creek	BW	333.4	LDB	33° 11.987	87° 39.627
9	19 May 93	Potato Creek	BW	332.9	RDB	33° 11.683	87° 39.668
10	20 May 93	Robinson Bend	BW	326.4	RDB	33° 10.370	87° 41.455
11	20 May 93	Robinson Bend	BW	326.2	RDB	33° 10.160	87° 41.480
12	20 May 93	Robinson Bend	BW	325.7	RDB	33° 09.890	87° 41.736
13	20 May 93	North Star Wreck	BW	325.2	LDB	33° 09.603	87° 42.132
14	20 May 93	North Star Wreck	BW	325.0	LDB	33° 09.544	87° 42.156
15	20 May 93	North Star Wreck	BW	324.5	RDB	33° 09.444	87° 41.738
16	20 May 93	North Star Wreck	BW	324.2	LDB	33° 09.276	87° 41.434
17	20 May 93	Mile 323 Bar	BW	323.7	LDB	33° 08.784	87° 41.421
18	20 May 93	Mile 323 Bar	BW	322.0	LDB	33° 08.131	87° 41.042
19	20 May 93	Fosters Ferry	BW	322.3	LDB	33° 07.856	87° 40.684
20	20 May 93	Fosters Ferry	BW	321.3	LDB	33° 07.374	87° 40.120
21	21 May 93	Eagle Shoals	BW	315.1	LDB	33° 06.047	87° 37.030
22	21 May 93	Eagle Shoals	BW	314.9	LDB	33° 05.961	87° 37.051
23	21 May 93	Kings Mountain	BW	312.1	RDB	33° 05.961	87° 37.051
24	21 May 93	Kings Mountain	BW	311.4	RDB	33° 04.663	87° 35.293
25	21 May 93	Hulls Landing	BW	309.4	RDB	33° 03.673	87° 36.569
26	21 May 93	Hulls Landing	BW	308.5	LDB	33° 03.629	87° 37.461
27	21 May 93	Hulls Landing	BW	308.3	RDB	33° 03.620	87° 37.815
28	21 May 93	Van Cleave/Lewis Bar	BW	305.6	LDB	33° 01.957	87° 37.955

(Sheet 1 of 3)

Note: RDB = Right Descending Bank; LDB = Left Descending Bank; Lat = Latitude; Long = Longitude.

**Table A1 (Continued)**

<b>Dive No.</b>	<b>Date</b>	<b>Description</b>	<b>River</b>	<b>Mile</b>	<b>Bank</b>	<b>Lat</b>	<b>Long</b>
29	21 May 93	Van Cleave/Lewis Bar	BW	305.3	RDB	33° 01.875	87° 27.977
30	21 May 93	McGowin Bluff	BW	304.8	LDB	33° 01.875	87° 37.977
31	21 May 93	McGowin Bluff	BW	304.0	RDB	33° 01.342	87° 37.812
32	21 May 93	McGowin Bluff	BW	303.8	RDB	33° 00.809	87° 37.639
33	21 May 93	Mud Bar	BW	302.5	RDB	33° 00.768	87° 37.738
34	21 May 93	Mud Bar	BW	302.2	RDB	33° 00.762	87° 37.738
35	22 May 93	Ala. Elec. Co-op	T	90.3	RDB	31° 29.796	87° 54.911
36	22 May 93	Ala. Elec. Co-op	T	0.6	RDB	31° 29.877	87° 55.091
37	22 May 93	Blackwell's Bar	T	88.8	RDB	31° 28.736	87° 54.732
38	22 May 93	Blackwell's Bar	T	87.5	LDB	31° 27.695	87° 55.105
39	22 May 93	East Bassetts Bar	T	86.9	LDB	31° 27.258	87° 54.920
40	22 May 93	Side Lake Bayou	T	65.4	LDB	31° 17.963	87° 57.024
41	22 May 93	Green Lake	T	66.2	LDB	31° 18.407	87° 57.798
42	22 May 93	Lower Batchelors	T	74.4	LDB	31° 20.092	87° 54.290
43	22 May 93	Upper Batchelors	T	74.9	RDB	31° 20.242	87° 54.150
44	22 May 93	Sunflower Cut-off Bar	T	77.5	LDB	31° 22.335	87° 53.565
45	22 May 93	Sunflower Cut-off Bar	T	77.5	RDB	31° 22.290	87° 53.588
46	22 May 93	Sunflower Cut-off Bar	T	78.5	RDB	31° 23.055	87° 54.081
47	23 May 93	Morrows Rock	BW	281.3	LDB	32° 55.126	87° 46.393
48	23 May 93	Morrows Rock	BW	282.4	RDB	32° 55.614	87° 46.204
49	23 May 93	Morrows Rock	BW	281.8	LDB	32° 55.496	87° 46.543
50	23 May 93	Mary H. Bar	BW	283.4	LDB	32° 55.800	87° 45.874
51	23 May 93	Mary H. Bar	BW	283.3	LDB	32° 55.751	87° 45.880
52	23 May 93	Morrows Rock	BW	281.3	LDB	32° 55.139	87° 46.348
53	23 May 93	Old Lock No. 9	BW	293.0	RDB	32° 59.305	87° 42.585
54	23 May 93	Izzard Shoals	BW	293.7	LDB	32° 59.843	87° 42.480
55	23 May 93	Izzard Shoals	BW	293.9	LDB	32° 59.907	87° 42.591
56	23 May 93	Izzard Shoals	BW	294.4	LDB	33° 00.233	87° 42.837
57	23 May 93	Izzard Shoals	BW	294.4	RDB	33° 00.254	87° 42.894
58	23 May 93	Izzard Shoals	BW	295.0	RDB	33° 00.572	87° 42.990
59	23 May 93	Wildhorse Bar	BW	300.9	LDB	33° 01.680	87° 39.550

*(Sheet 2 of 3)*

<b>Table A1 (Concluded)</b>							
<b>Dive No.</b>	<b>Date</b>	<b>Description</b>	<b>River</b>	<b>Mile</b>	<b>Bank</b>	<b>Lat</b>	<b>Long</b>
60	23 May 93	Wildhorse Bar	BW	301.3	LDB	33° 01.777	87° 39.044
61	24 May 93	Smiths Island	T	189.3	LDB	32° 18.795	87° 56.282
62	24 May 93	Smiths Island	T	188.9	LDB	32° 18.590	87° 55.796
63	24 May 93	Smiths Island	T	188.6	RDB	32° 18.308	87° 55.733
64	24 May 93	Smiths Island	T	187.9	RDB	32° 17.958	87° 55.915
65	24 May 93	Rainwater Bar	T	187.7	LDB	32° 17.841	87° 55.851
66	24 May 93	Rainwater Bar	T	187.5	LDB	32° 17.623	87° 55.888
67	24 May 93	Waites Landing	T	106.8	LDB	31° 38.997	88° 05.259
68	24 May 93	Waites Landing	T	106.2	RDB	31° 38.629	88° 05.190
69	24 May 93	St. Elmo Bar	T	95.3	LDB	31° 32.071	87° 58.532

**Table A2**  
**Water Depth, Replicate Number, and Field Notes for Dredged Material**  
**Disposal Areas Surveyed Along the Black Warrior and Tombigbee Rivers,**  
**Alabama, 19-24 May 1993**

Dive No.	Description	Max Depth ft	Replicate No.	Field Notes
1	Clements Bend	17	1	Loose sand, steep slope
2	Clements Bend	15	2	8 to 10 in. of sand over clay, gradual slope
3	Clements Bend	16	3	Gravel (<1.5-in. diameter) and sand
4	Clements Bend	15	4	Loose sand, gradual slope
5	Clements Bend	5	5	Loose sand
6	Potato Creek	21	1	Sand, gradual slope
7	Potato Creek	29	2	Sand mixed with gravel
8	Potato Creek	15	3	Sand mixed with gravel
9	Potato Creek	15	4	Coarse sand, change to packed clay near channel
10	Robinson Bend	15	1	Loose sand nearshore, and small bands of gravel offshore
11	Robinson Bend	15	2	Loose sand
12	Robinson Bend	15	3	Loose sand
13	North Star Wreck	22	1	Loose sand
14	North Star Wreck	20	2	Loose sand
15	North Star Wreck	15	3	Sand mixed with gravel
16	North Star Wreck	14	4	Loose sand and some clay
17	Mile 323 Bar	10	1	Coarse sand
18	Mile 323 Bar	9	2	Loose sand
19	Fosters Ferry	31	1	Sand and silt
20	Fosters Ferry	13	2	Sand
21	Eagle Shoals	11.5	1	Coarse sand and gravel
22	Eagle Shoals	11	2	Coarse sand and gravel
23	Kings Mountain	12	1	Sand and silt
24	Kings Mountain	15	2	Sand and silt
25	Hulls Bar Landing	9	1	Sand and silt
26	Hulls Bar Landing	10	2	Sand and coarse gravel

(Sheet 1 of 3)

<b>Table A2 (Continued)</b>				
<b>Dive No.</b>	<b>Description</b>	<b>Max Depth ft</b>	<b>Replicate No.</b>	<b>Field Notes</b>
27	Hulls Bar Landing	19	3	Hard packed clay with small to large gravel
28	Van Cleave/Lewis Bar	15	1	Silt and sand
29	Van Cleave/Lewis Bar	13	2	Gravel and sand, logs and detritus
30	McGowin Bluff	13	1	Coarse sand
31	McGowin Bluff	10	2	Sand
32	McGowin Bluff	10	3	Coarse sand
33	Mud Bar	11	1	Sand
34	Mud Bar	11	2	Coarse sand
35	Ala. Elec. Co-op	13	1	Fine sand and 4 in. of silt
36	Ala. Elec. Co-op	21.5	2	Fine sand
37	Blackwell's Bar	15	1	Sand and gravel
38	Blackwell's Bar	9	2	Coarse sand
39	East Bassetts Bar	18	1	Mud grading into sand moving offshore
40	Side Lake Bayou	15	1	Fine sand
41	Green Lake	14	1	Very fine sand
42	Lower Batchelors	21	1	Very fine sand
43	Upper Batchelors	14	2	Very fine sand
44	Sunflower Cut-off Bar	15	1	Silt and sand
45	Sunflower Cut-off Bar	15	2	Sand and gravel
46	Sunflower Cut-off Bar	13	3	Large gravel and sand
47	Morrows Rock	23	1	Loose sand over hard packed, silty sand
48	Morrows Rock	16	2	Hard packed sand
49	Morrows Rock	17	3	Fine sand with some silt on top
50	Mary H. Bar	11	1	Sand
51	Mary H. Bar	23	2	Silt over sand substrate
52	Morrows Rock	12	4	Sand and silt
<i>(Sheet 2 of 3)</i>				

<b>Table A2 (Concluded)</b>				
<b>Dive No.</b>	<b>Description</b>	<b>Max Depth ft</b>	<b>Replicate No.</b>	<b>Field Notes</b>
53	Old Lock No. 9	12	1	Sand and cobble (75 to 100 mm in diameter)
54	Izzard Shoals	12	1	Sand
55	Izzard Shoals	10	2	Stable sand
56	Izzard Shoals	11	3	Sand
57	Izzard Shoals	14	4	Gravel, cobble, and tree limbs
58	Izzard Shoals	12	5	Sand and silt
59	Wildhorse Bar	13	1	Loose sand
60	Wildhorse Bar	10	2	Hard sand
61	Smiths Island	10	1	Coarse sand
62	Smiths Island	14	2	Fine sand
63	Smiths Island	10	3	Coarse sand and small amount of gravel
64	Smiths Island	13	4	Fine sand
65	Rainwater Bar	17	1	Coarse sand
66	Rainwater Bar	8	2	Coarse sand and small amount of gravel
67	Waites Landing	12	1	Sand mixed with gravel and cobble
68	Waites Landing	11	2	Sand
69	St. Elmo Bar	10	1	Sand
<i>(Sheet 3 of 3)</i>				

**Table A3**  
**Summary of Information Collected by Diver 1, Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. inflatus</i>	Bivalves/min	<i>P. Inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. Inflatus</i> /100 sq m
1	17	1	0	0	0.059	0.000	85	1.176	0.000
2	12	0	0	0	0.000	0.000	60	0.000	0.000
3	10	0	0	0	0.000	0.000	50	0.000	0.000
4	12	0	0	0	0.000	0.000	60	0.000	0.000
5	27	0	0	0	0.000	0.000	135	0.000	0.000
6	24	1	1	0	0.042	0.000	120	0.833	0.000
7	23	0	0	0	0.000	0.000	115	0.000	0.000
8	12	0	0	0	0.000	0.000	60	0.000	0.000
9	13	0	0	0	0.000	0.000	65	0.000	0.000
10	11	0	0	0	0.000	0.000	55	0.000	0.000
11	13	0	0	0	0.000	0.000	65	0.000	0.000
12	13	0	0	0	0.000	0.000	65	0.000	0.000
13	15	0	0	0	0.000	0.000	75	0.000	0.000
14	12	0	0	0	0.000	0.000	60	0.000	0.000

(Sheet 1 of 5)

Table A3 (Continued)

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. inflatus</i>	Bivalves/min	<i>P. inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. inflatus</i> /100 sq m
15	13	0	0	0	0.000	0.000	65	0.000	0.000
16	14	2	2	1	0.143	0.071	70	2.857	1.429
17	14	0	0	0	0.000	0.000	70	0.000	0.000
18	12	0	0	0	0.000	0.000	60	0.000	0.000
19	15	2	1	2	0.133	0.133	75	2.667	2.667
20	14	0	0	0	0.000	0.000	70	0.000	0.000
21	13	1	1	0	0.077	0.000	65	1.538	0.000
22	12	1	1	1	0.083	0.083	60	1.667	1.667
23	11	0	0	0	0.000	0.000	55	0.000	0.000
24	13	0	0	0	0.000	0.000	65	0.000	0.000
25	5	0	0	0	0.000	0.000	25	0.000	0.000
26	12	1	1	1	0.083	0.083	60	1.667	1.667
27	12	0	0	0	0.000	0.000	60	0.000	0.000
28	11	1	1	1	0.091	0.091	55	1.818	1.818
29	7	0	0	0	0.000	0.000	35	0.000	0.000

(Sheet 2 of 5)

Table A3 (Continued)										
Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/min	<i>P. Inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. Inflatus</i> /100 sq m	
30	7	0	0	0	0.000	0.000	35	0.000	0.000	
31	13	1	1	1	0.077	0.077	65	1.538	1.538	
32	2	1	1	1	0.500	0.500	10	10.000	10.000	
33	10	1	1	0	0.100	0.100	50	2.000	2.000	
34	10	1	1	1	0.100	0.100	50	2.000	2.000	
35	10	0	0	0	0.000	0.000	50	0.000	0.000	
36	11	0	0	0	0.000	0.000	55	0.000	0.000	
37	10	0	0	0	0.000	0.000	50	0.000	0.000	
38	10	0	0	0	0.000	0.000	50	0.000	0.000	
39	11	0	0	0	0.000	0.000	55	0.000	0.000	
40	10	0	0	0	0.000	0.000	50	0.000	0.000	
41	10	0	0	0	0.000	0.000	50	0.000	0.000	
42	10	1	1	0	0.100	0.000	50	2.000	0.000	
43	12	0	0	0	0.000	0.000	60	0.000	0.000	
44	10	0	0	0	0.000	0.000	50	0.000	0.000	
(Sheet 3 of 5)										

Table A3 (Continued)										
Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. inflatus</i>	Bivalves/min	<i>P. inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. inflatus</i> /100 sq m	
45	10	0	0	0	0.000	0.000	50	0.000	0.000	
46	10	0	0	0	0.000	0.000	50	0.000	0.000	
47	3	2	2	1	0.667	0.333	15	13.333	6.667	
48	10	1	1	0	0.100	0.000	50	2.000	0.000	
49	11	0	0	0	0.000	0.000	55	0.000	0.000	
50	10	0	0	0	0.000	0.000	50	0.000	0.000	
51	10	0	0	0	0.000	0.000	50	0.000	0.000	
52	13	0	0	0	0.000	0.000	65	0.000	0.000	
53	10	0	0	0	0.000	0.000	50	0.000	0.000	
54	13	0	0	0	0.000	0.000	65	0.000	0.000	
55	9	0	0	0	0.000	0.000	45	0.000	0.000	
56	10	0	0	0	0.000	0.000	50	0.000	0.000	
57	10	0	0	0	0.000	0.000	50	0.000	0.000	
58	11	1	1	1	0.091	0.091	55	1.818	1.818	
59	12	0	0	0	0.000	0.000	60	0.000	0.000	
(Sheet 4 of 5)										

Table A3 (Concluded)

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. inflatus</i>	Bivalves/min	<i>P. inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. inflatus</i> /100 sq m
60	12	2	2	1	0.167	0.083	60	3.333	1.667
61	10	0	0	0	0.000	0.000	50	0.000	0.000
62	13	0	0	0	0.000	0.000	65	0.000	0.000
63	13	0	0	0	0.000	0.000	65	0.000	0.000
64	13	1	1	0	0.077	0.000	65	1.538	0.000
65	11	0	0	0	0.000	0.000	55	0.000	0.000
66	14	1	1	0	0.071	0.000	70	1.429	0.000
67	11	0	0	0	0.000	0.000	55	0.000	0.000
68	15	0	0	0	0.000	0.000	75	0.000	0.000
69	11	1	1	0	0.091	0.000	55	1.818	0.000

(Sheet 5 of 5)

**Table A4**  
**Summary of Information Collected by Diver 2, Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/min	<i>P. Inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. Inflatus</i> /100 sq m
1	19	0	0	0	0.000	0.000	95	0.000	0.000
2	13	0	0	0	0.000	0.000	65	0.000	0.000
3	9	0	0	0	0.000	0.000	45	0.000	0.000
4	15	1	1	1	0.067	0.067	75	1.333	1.333
5	11	0	0	0	0.000	0.000	55	0.000	0.000
6	24	0	0	0	0.000	0.000	120	0.000	0.000
7	22	0	0	0	0.000	0.000	110	0.000	0.000
8	12	0	0	0	0.000	0.000	60	0.000	0.000
9	13	0	0	0	0.000	0.000	65	0.000	0.000
10	15	0	0	0	0.000	0.000	75	0.000	0.000
11	13	0	0	0	0.000	0.000	65	0.000	0.000
12	15	0	0	0	0.000	0.000	75	0.000	0.000
13	13	0	0	0	0.000	0.000	65	0.000	0.000
14	14	0	0	0	0.000	0.000	70	0.000	0.000

(Sheet 1 of 5)

**(Sheet 2 of 5)**

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/min	<i>P. Inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. Inflatus</i> /100 sq m
15	13	0	0	0	0.000	0.000	65	0.000	0.000
16	13	0	0	0	0.000	0.000	65	0.000	0.000
17	13	0	0	0	0.000	0.000	65	0.000	0.000
18	12	0	0	0	0.000	0.000	60	0.000	0.000
19	12	2	1	2	0.167	0.167	60	3.333	3.333
20	15	1	1	1	0.067	0.067	75	1.333	1.333
21	12	0	0	0	0.000	0.000	60	0.000	0.000
22	10	0	0	0	0.000	0.000	50	0.000	0.000
23	10	1	1	1	0.100	0.100	50	2.000	2.000
24	11	1	1	1	0.091	0.091	55	1.818	1.818
25	3	2	1	2	0.667	0.667	15	13.333	13.333
26	11	0	0	0	0.000	0.000	55	0.000	0.000
27	11	0	0	0	0.000	0.000	55	0.000	0.000
28	12	0	0	0	0.000	0.000	60	0.000	0.000
29	7	2	2	0	0.286	0.000	35	5.714	0.000

Table A4 (Continued)										
Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/min	<i>P. Inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. Inflatus</i> /100 sq m	
30	9	1	1	1	0.111	0.111	45	2.222	2.222	
31	12	3	2	2	0.250	0.167	60	5.000	3.333	
32	0	0	0	0	0.000	0.000	0	0.000	0.000	
33	13	0	0	0	0.000	0.000	65	0.000	0.000	
34	10	3	3	1	0.300	0.100	50	6.000	2.000	
35	10	0	0	0	0.000	0.000	50	0.000	0.000	
36	10	1	1	0	0.100	0.000	50	2.000	0.000	
37	11	0	0	0	0.000	0.000	55	0.000	0.000	
38	10	0	0	0	0.000	0.000	50	0.000	0.000	
39	13	0	0	0	0.000	0.000	65	0.000	0.000	
40	11	0	0	0	0.000	0.000	55	0.000	0.000	
41	10	0	0	0	0.000	0.000	50	0.000	0.000	
42	11	0	0	0	0.000	0.000	55	0.000	0.000	
43	11	0	0	0	0.000	0.000	55	0.000	0.000	
44	11	0	0	0	0.000	0.000	55	0.000	0.000	
(Sheet 3 of 5)										

Table A4 (Continued)									
Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/min	<i>P. Inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. Inflatus</i> /100 sq m
45	10	0	0	0	0.000	0.000	50	0.000	0.000
46	10	0	0	0	0.000	0.000	50	0.000	0.000
47	5	1	1	0	0.200	0.000	25	4.000	0.000
48	10	0	0	0	0.000	0.000	50	0.000	0.000
49	10	0	0	0	0.000	0.000	50	0.000	0.000
50	10	4	3	1	0.400	0.100	50	8.000	2.000
51	11	0	0	0	0.000	0.000	55	0.000	0.000
52	13	3	3	0	0.231	0.000	65	4.615	0.000
53	12	3	0	0	0.250	0.000	60	5.000	0.000
54	10	0	0	0	0.000	0.000	50	0.000	0.000
55	11	0	0	0	0.000	0.000	55	0.000	0.000
56	11	1	1	1	0.091	0.091	55	1.818	1.818
57	10	0	0	0	0.000	0.000	50	0.000	0.000
58	10	1	1	0	0.100	0.000	50	2.000	0.000
59	13	5	2	4	0.385	0.308	65	7.692	6.154
(Sheet 4 of 5)									

Table A4 (Concluded)										
Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/ min	<i>P. Inflatus</i> / min	Area Searched sq m	Bivalves/ 100 sq m	<i>P. Inflatus</i> / 100 sq m	
60	11	2	2	1	0.182	0.091	55	3.636	1.818	
61	10	0	0	0	0.000	0.000	50	0.000	0.000	
62	12	1	1	1	0.083	0.083	60	1.667	1.667	
63	12	0	0	0	0.000	0.000	60	0.000	0.000	
64	11	0	0	0	0.000	0.000	55	0.000	0.000	
65	12	0	0	0	0.000	0.000	60	0.000	0.000	
66	12	0	0	0	0.000	0.000	60	0.000	0.000	
67	11	0	0	0	0.000	0.000	55	0.000	0.000	
68	12	0	0	0	0.000	0.000	60	0.000	0.000	
69	13	0	0	0	0.000	0.000	65	0.000	0.000	
(Sheet 5 of 5)										

**Table A5**  
**Summary of Information Collected by Divers 1 and 2, Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/min	<i>P. Inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. inflatus</i> /100 sq m
1	36	1	1	0	0.028	0.000	180	0.556	0.000
2	25	0	0	0	0.000	0.000	125	0.000	0.000
3	19	0	0	0	0.000	0.000	95	0.000	0.000
4	27	1	1	1	0.037	0.037	135	0.741	0.741
5	38	0	0	0	0.000	0.000	190	0.000	0.000
6	48	1	1	0	0.021	0.000	240	0.417	0.000
7	45	0	0	0	0.000	0.000	225	0.000	0.000
8	24	0	0	0	0.000	0.000	120	0.000	0.000
9	26	0	0	0	0.000	0.000	130	0.000	0.000
10	26	0	0	0	0.000	0.000	130	0.000	0.000
11	26	0	0	0	0.000	0.000	130	0.000	0.000
12	28	0	0	0	0.000	0.000	140	0.000	0.000
13	28	0	0	0	0.000	0.000	140	0.000	0.000
14	26	0	0	0	0.000	0.000	130	0.000	0.000
(Sheet 1 of 5)									

Table A5 (Continued)

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. inflatus</i>	Bivalves/ min	<i>P. inflatus</i> / min	Area Searched sq m	Bivalves/ 100 sq m	<i>P. inflatus</i> / 100 sq m
15	26	0	0	0	0.000	0.000	130	0.000	0.000
16	27	2	2	1	0.074	0.037	135	1.481	0.741
17	27	0	0	0	0.000	0.000	135	0.000	0.000
18	24	0	0	0	0.000	0.000	120	0.000	0.000
19	27	4	1	4	0.148	0.148	135	2.963	2.963
20	29	1	1	1	0.034	0.034	145	0.690	0.690
21	25	1	1	0	0.040	0.000	125	0.800	0.000
22	22	1	1	1	0.045	0.045	110	0.909	0.909
23	21	1	0	1	0.048	0.048	105	0.952	0.952
24	24	1	0	1	0.042	0.042	120	0.833	0.833
25	8	2	1	2	0.250	0.250	40	5.000	5.000
26	23	1	1	1	0.043	0.043	115	0.870	0.870
27	23	0	0	0	0.000	0.000	115	0.000	0.000
28	23	1	1	1	0.043	0.043	115	0.870	0.870
29	14	2	2	0	0.143	0.000	70	2.857	0.000

(Sheet 2 of 5)

Table A5 (Continued)										
Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. Inflatus</i>	Bivalves/ min	<i>P. Inflatus</i> / min	Area Searched sq m	Bivalves/ 100 sq m	<i>P. Inflatus</i> / 100 sq m	
30	16	1	1	1	0.063	0.063	80	1.250	1.250	
31	25	4	2	3	0.160	0.120	125	3.200	2.400	
32	2	1	1	1	0.500	0.500	10	10.000	10.000	
33	23	1	1	0	0.043	0.043	115	0.870	0.870	
34	20	4	3	2	0.200	0.100	100	4.000	2.000	
35	20	0	0	0	0.000	0.000	100	0.000	0.000	
36	21	1	1	0	0.048	0.000	105	0.952	0.000	
37	21	0	0	0	0.000	0.000	105	0.000	0.000	
38	20	0	0	0	0.000	0.000	100	0.000	0.000	
39	24	0	0	0	0.000	0.000	120	0.000	0.000	
40	21	0	0	0	0.000	0.000	105	0.000	0.000	
41	20	0	0	0	0.000	0.000	100	0.000	0.000	
42	21	1	1	0	0.048	0.000	105	0.952	0.000	
43	23	0	0	0	0.000	0.000	115	0.000	0.000	
44	21	0	0	0	0.000	0.000	105	0.000	0.000	
(Sheet 3 of 5)										

Table A5 (Continued)										
Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. inflatus</i>	Bivalves/ min	<i>P. inflatus</i> / min	Area Searched sq m	Bivalves/ 100 sq m	<i>P. inflatus</i> / 100 sq m	
45	20	0	0	0	0.000	0.000	100	0.000	0.000	
46	20	0	0	0	0.000	0.000	100	0.000	0.000	
47	8	3	3	1	0.375	0.125	40	7.500	2.500	
48	20	1	1	0	0.050	0.000	100	1.000	0.000	
49	21	0	0	0	0.000	0.000	105	0.000	0.000	
50	20	4	3	1	0.200	0.050	100	4.000	1.000	
51	21	0	0	0	0.000	0.000	105	0.000	0.000	
52	26	3	3	0	0.115	0.000	130	2.308	0.000	
53	22	3	3	1	0.136	0.045	110	2.727	0.909	
54	23	0	0	0	0.000	0.000	115	0.000	0.000	
55	20	0	0	0	0.000	0.000	100	0.000	0.000	
56	21	1	1	1	0.048	0.048	105	0.952	0.952	
57	20	0	0	0	0.000	0.000	100	0.000	0.000	
58	21	2	2	1	0.095	0.048	105	1.905	0.952	
59	25	5	2	4	0.200	0.160	125	4.000	3.200	
(Sheet 4 of 5)										

(Sheet 5 of 5)

Dive No.	Time min	Total Bivalves	Total Species	Total <i>P. inflatus</i>	Bivalves/min	<i>P. inflatus</i> /min	Area Searched sq m	Bivalves/100 sq m	<i>P. inflatus</i> /100 sq m
60	23	4	3	2	0.174	0.087	115	3.478	1.739
61	20	0	0	0	0.000	0.000	100	0.000	0.000
62	25	1	1	1	0.040	0.040	125	0.800	0.800
63	25	0	0	0	0.000	0.000	125	0.000	0.000
64	24	1	1	0	0.042	0.000	120	0.833	0.000
65	23	0	0	0	0.000	0.000	115	0.000	0.000
66	26	1	1	0	0.038	0.000	130	0.769	0.000
67	22	0	0	0	0.000	0.000	110	0.000	0.000
68	27	0	0	0	0.000	0.000	135	0.000	0.000
69	24	1	1	0	0.042	0.000	120	0.833	0.000

**Table A6**  
**Shell Length for Freshwater Bivalves Collected by Divers in the**  
**Black Warrior and Tombigbee Rivers, Alabama, 19-24 May 1993**  
**(Value -1 = no data)**

May 1994 (Day)	Site Number	Replicate Number	Species	Dive Number	Total Length mm	Total Width mm
19	2	4	<i>P. inflatus</i>	4	137.20	44.30
19	1	1	<i>Q. apiculata</i>	6	61.00	-1.00
20	4	4	<i>O. reflexa</i>	16	36.90	-1.00
20	4	4	<i>P. inflatus</i>	16	46.50	13.50
20	6	1	<i>P. inflatus</i>	19	69.30	22.00
20	6	1	<i>P. inflatus</i>	19	33.20	9.90
20	6	1	<i>P. inflatus</i>	19	78.70	23.40
20	6	1	<i>P. inflatus</i>	19	121.80	37.00
20	6	2	<i>P. inflatus</i>	20	47.00	12.90
21	7	1	<i>L. complanata</i>	21	100.10	25.00
21	7	2	<i>P. inflatus</i>	22	126.30	44.50
21	7a	1	<i>P. inflatus</i>	23	91.80	26.80
21	7a	2	<i>P. inflatus</i>	24	107.50	41.10
21	8	1	<i>P. inflatus</i>	25	66.40	18.70
21	8	1	<i>P. inflatus</i>	25	36.10	9.70
21	8	2	<i>P. inflatus</i>	26	124.20	41.80
21	9	1	<i>P. inflatus</i>	28	51.20	14.40
21	9	2	<i>O. reflexa</i>	29	50.60	-1.00
21	9	2	<i>Q. apiculata</i>	29	60.10	-1.00
21	10	1	<i>P. inflatus</i>	30	117.20	39.90
21	10	2	<i>P. inflatus</i>	31	109.50	34.80
21	10	2	<i>P. purpurata</i>	31	100.10	-1.00
21	10	2	<i>P. inflatus</i>	31	39.30	10.20
21	10	2	<i>P. inflatus</i>	31	115.20	39.40
21	10	3	<i>P. inflatus</i>	32	46.80	13.40
21	11	1	<i>O. reflexa</i>	33	31.50	-1.00

(Sheet 1 of 3)

Note: *C. fluminea* - Asian clam, *L. complanata* - white heelsplitter, *L. fragilis* - fragile paper-shell, *L. teres* - yellow sandshell, *O. reflexa* - threehorn wartyback, *P. purpurata* - bleuter, *Q. apiculata* - southern mapleleaf, *Q. rumphiana* - ridged mapleleaf

Table A6 (Continued)						
May 1994 (Day)	Site Number	Replicate Number	Species	Dive Number	Total Length mm	Total Width mm
21	11	2	<i>P. inflatus</i>	34	78.00	23.80
21	11	2	<i>P. inflatus</i>	34	86.00	27.00
21	11	2	<i>C. fluminea</i>	34	12.00	-1.00
21	11	2	<i>L. fragilis</i>	34	86.90	-1.00
22	22	1	<i>L. fragilis</i>	42	68.40	-1.00
22	20a	2	<i>L. fragilis</i>	36	71.20	-1.00
23	16	1	<i>P. inflatus</i>	37	126.60	-1.00
23	16	1	<i>L. fragilis</i>	47	93.20	-1.00
23	16	2	<i>L. teres</i>	48	84.70	-1.00
23	15	1	<i>C. fluminea</i>	50	20.00	-1.00
23	15	1	<i>P. inflatus</i>	50	71.70	-1.00
23	15	1	<i>Q. rumphiana</i>	50	69.20	-1.00
23	15	1	<i>Q. apiculata</i>	50	48.80	-1.00
23	16	4	<i>Q. apiculata</i>	52	28.40	-1.00
23	16	4	<i>C. fluminea</i>	52	29.40	-1.00
23	16	4	<i>L. fragilis</i>	52	92.70	-1.00
23	14	1	<i>P. inflatus</i>	53	65.20	-1.00
23	14	1	<i>L. fragilis</i>	53	85.40	-1.00
23	14	1	<i>Q. apiculata</i>	53	62.90	-1.00
23	13	3	<i>P. inflatus</i>	56	110.40	37.10
23	13	5	<i>P. inflatus</i>	58	113.90	43.10
23	13	5	<i>Q. apiculata</i>	58	86.10	-1.00
23	12	1	<i>O. reflexa</i>	59	46.50	-1.00
23	12	1	<i>P. inflatus</i>	59	123.00	41.60
23	12	1	<i>P. inflatus</i>	59	111.50	40.40
23	12	1	<i>P. inflatus</i>	59	117.30	39.90
23	12	1	<i>P. inflatus</i>	59	117.10	40.60
23	12	2	<i>P. inflatus</i>	60	55.30	14.20
23	12	2	<i>C. fluminea</i>	60	22.00	-1.00
23	12	2	<i>P. inflatus</i>	60	87.20	25.50
(Sheet 2 of 3)						

Table A6 (Concluded)						
May 1994 (Day)	Site Number	Replicate Number	Species	Dive Number	Total Length mm	Total Width mm
23	12	2	<i>O. reflexa</i>	60	28.00	-1.00
19	2	1	<i>C. fluminea</i>	1	24.00	-1.00
24	17	2	<i>P. inflatus</i>	62	71.20	21.00
24	17	4	<i>C. fluminea</i>	64	9.00	-1.00
24	18	2	<i>L. fragilis</i>	66	49.80	-1.00
24	20	1	<i>L. fragilis</i>	69	65.60	-1.00
24	16	1	<i>C. fluminea</i>	47	18.30	-1.00
(Sheet 3 of 3)						

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
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13. ABSTRACT (Maximum 200 words)  On 19-24 May 1993, a survey was conducted at dredged material disposal areas located between River Mile (RM) 293.0 and RM 334.0 on the Tombigbee River and between RM 65.0 and RM 190.0 on the Black Warrior River, Alabama. The purpose was to search for freshwater mussels (Family: Unionidae), especially the inflated heelsplitter mussel <i>Potamilus inflatus</i> , listed as threatened by the U.S. Fish and Wildlife Service. A total of 69 locations at 28 disposal areas were searched by two divers equipped with surface-supplied air and communication equipment. Total bivalves (which included native mussels as well as the Asian clam <i>Corbicula fluminea</i> ) ranged from 0.104 to 4.817/100 sq m. When present, mussels were collected at a rate of 0.005 to 0.241/minute. The maximum density of <i>P. inflatus</i> was 4.5/100 sq m collected at a rate of 0.228/minute. A total of 1,610 min (26.8 hr) were spent searching for mussels. After about 1,000 min had been expended, nine species of bivalves (the total collected) were found. Of the 63 bivalves collected during the survey, 52.4 percent were <i>P. inflatus</i> and 12.7 percent were <i>Leptodea fragilis</i> . Thick-shelled species, usually found in firmly packed gravel substratum, comprised only 19 percent of the fauna. Based upon estimates of size up disposal areas and collecting rates, the total number of inflated heelsplitters at the 28 disposal areas could be as high as 7,180. A total of 2,120 diver hours could be required to collect all <i>P. inflatus</i> at these disposal areas. (Continued)				
14. SUBJECT TERMS Black Warrior River Molluscs <i>Potamilus inflatus</i>		Threatened species Tombigbee River		15. NUMBER OF PAGES 78
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13. (Concluded).

All of these disposal areas are not used each year. Between 1981 and 1992, the number of years since last dredging at the 28 areas studied ranged from 1 to 10. The total number of years within this time period that disposal took place ranged from 1 to 8. Relationships between total material dredged, total number of years when dredging took place, and the total number of years since the last dredging were nonsignificant ( $p > 0.05$ ).